

Aerosol Calculations with GMI Model

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University of Michigan

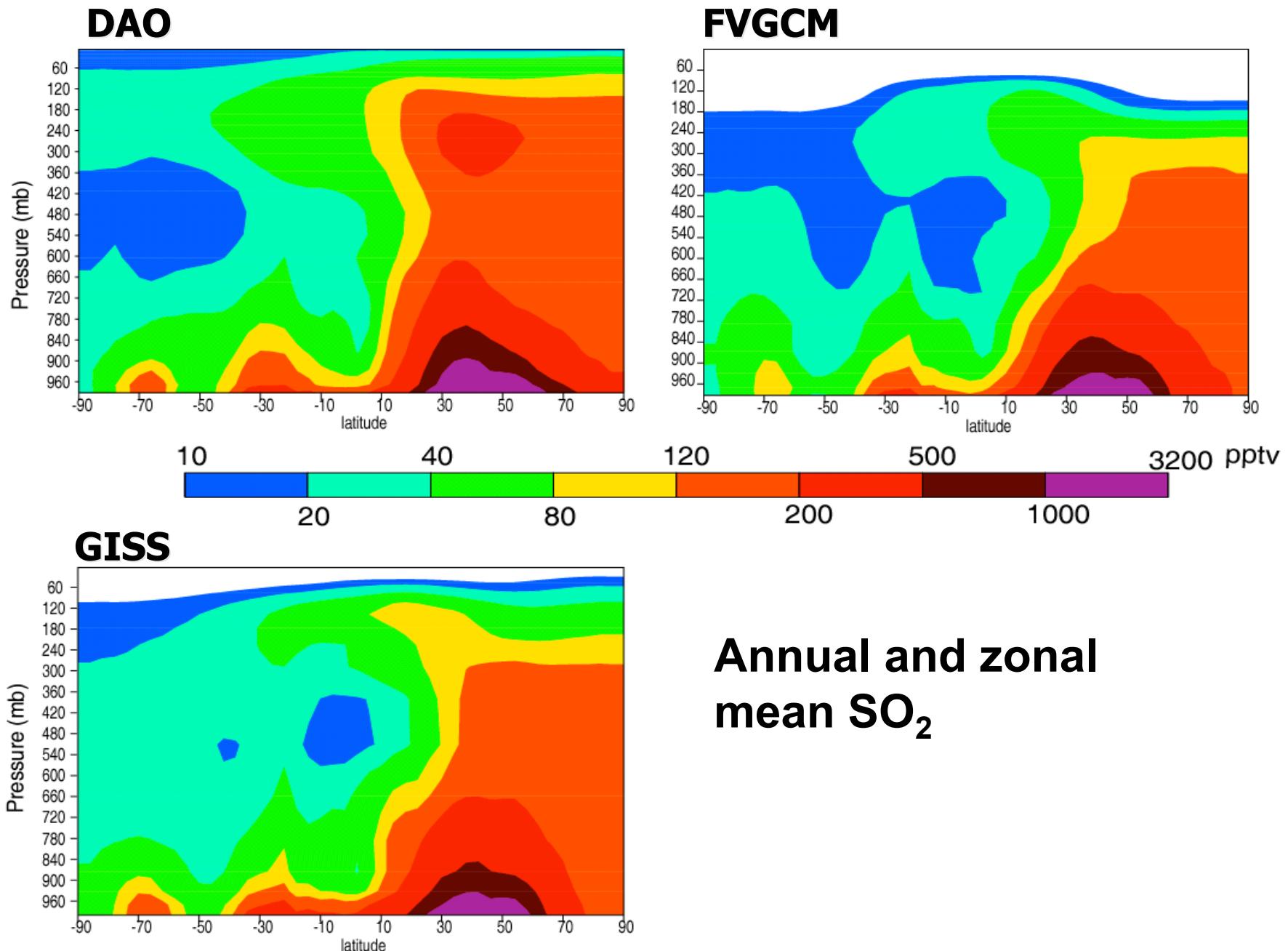
Thanks to GMI core team: Susan Strahan, Bigyani Das,
Jose Rodriguez, ...

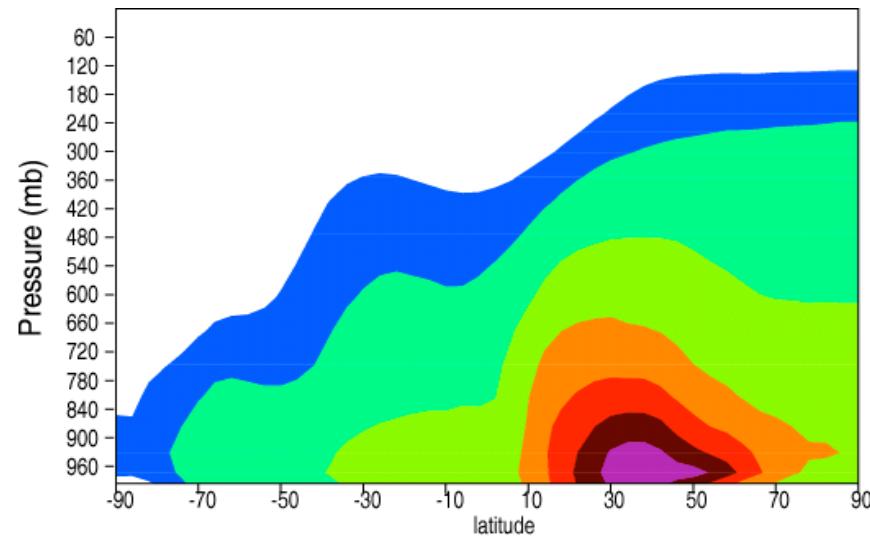
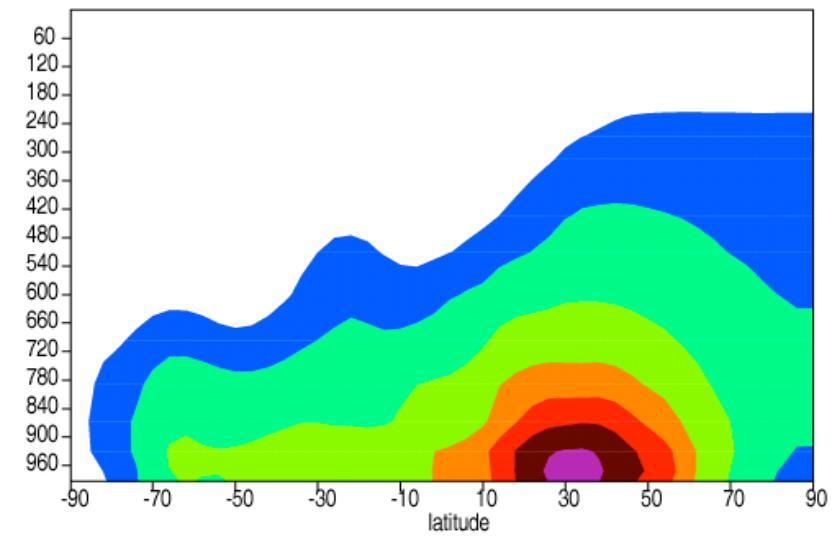
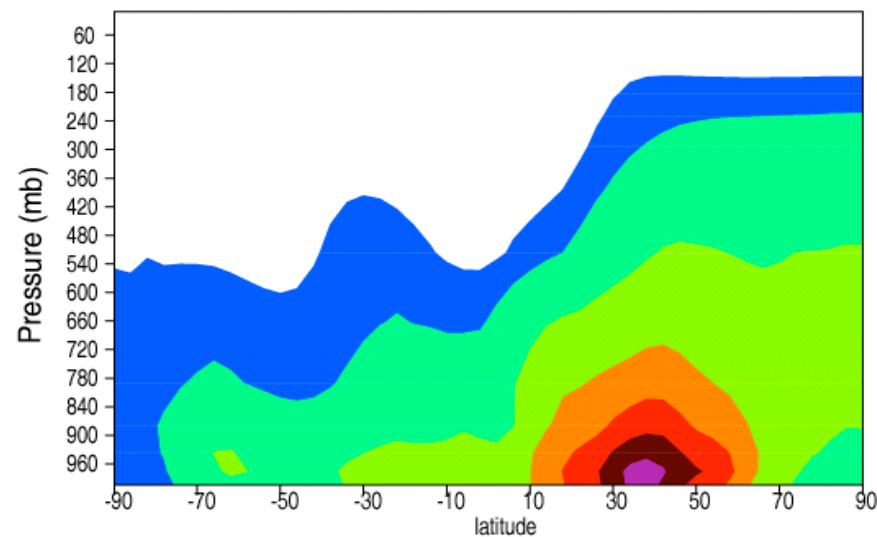
Outline

- **GMI aerosol model**
- **Aerosol calculations & evaluation**
- **Aerosol optical depth and direct radiative forcing**
- **Summary**

GMI Aerosol Model

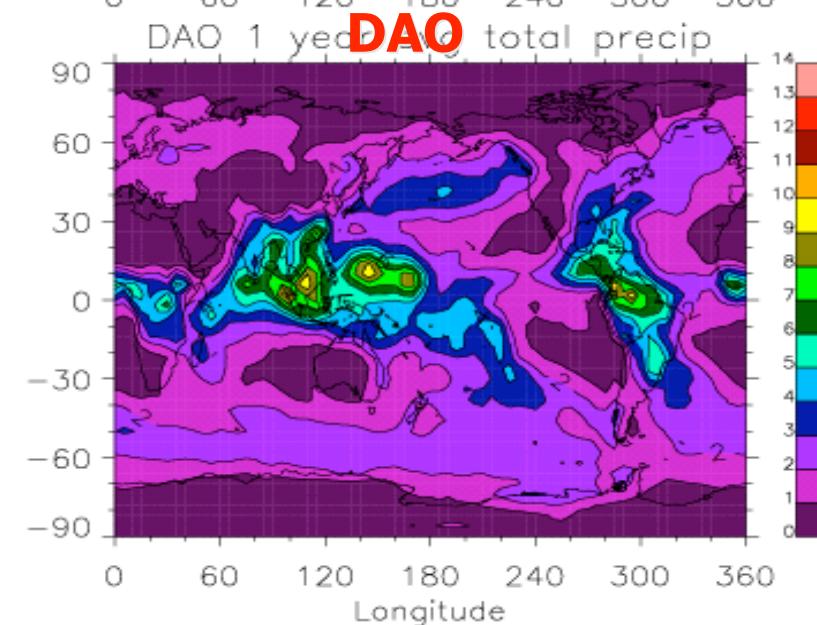
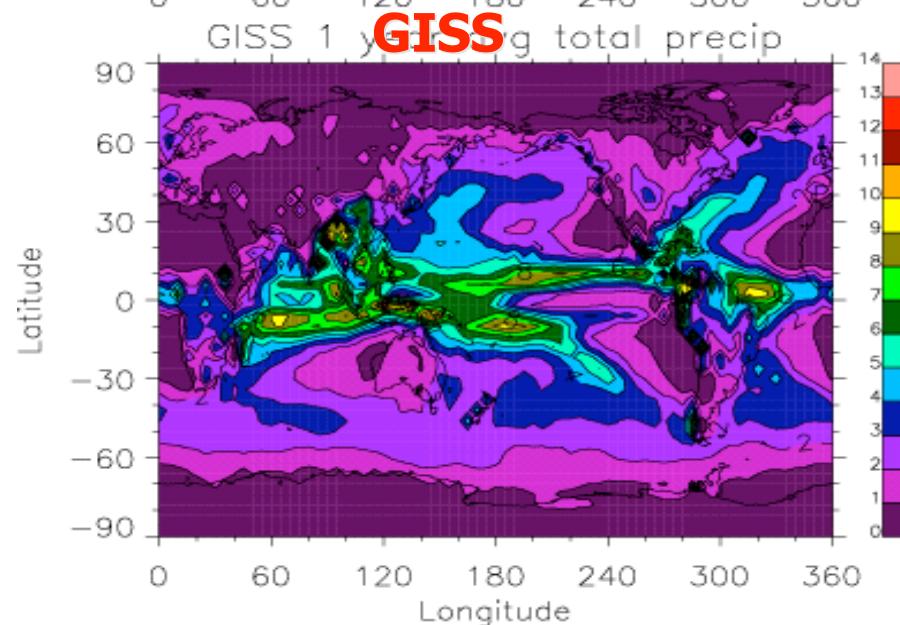
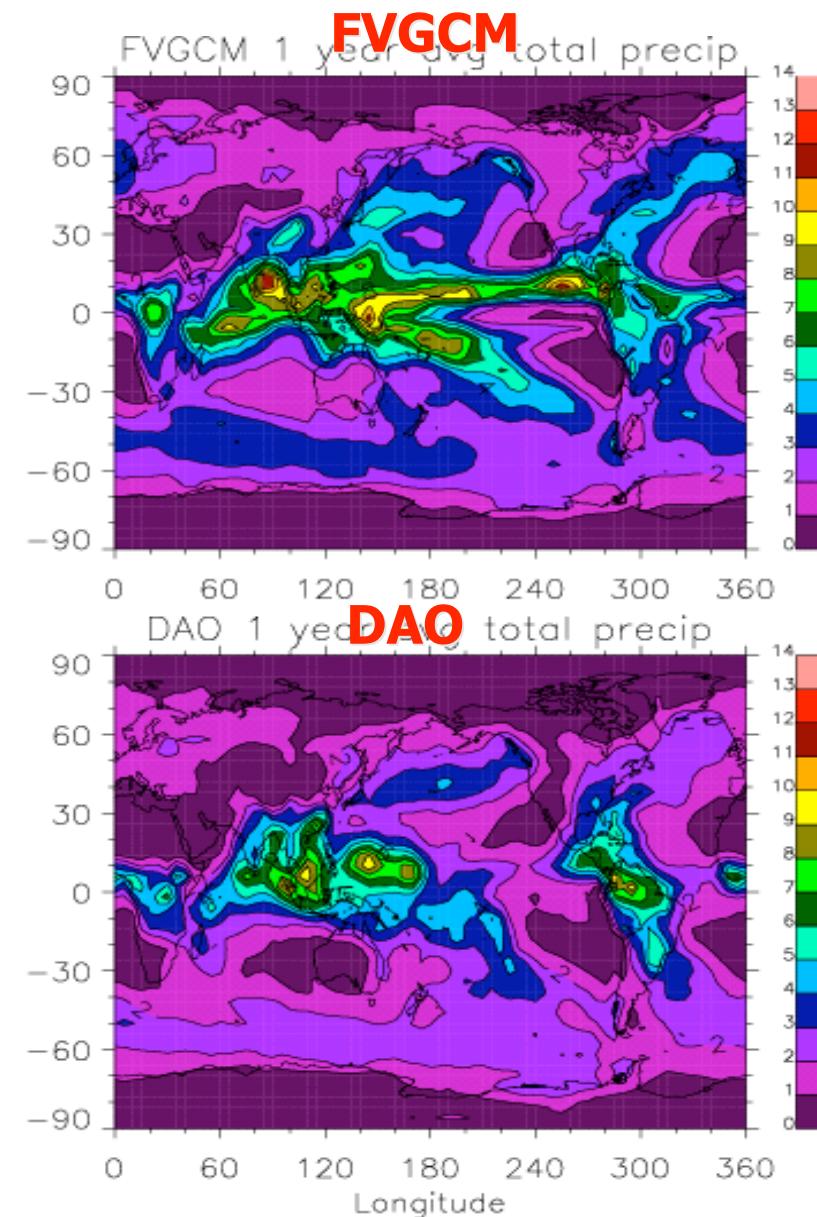
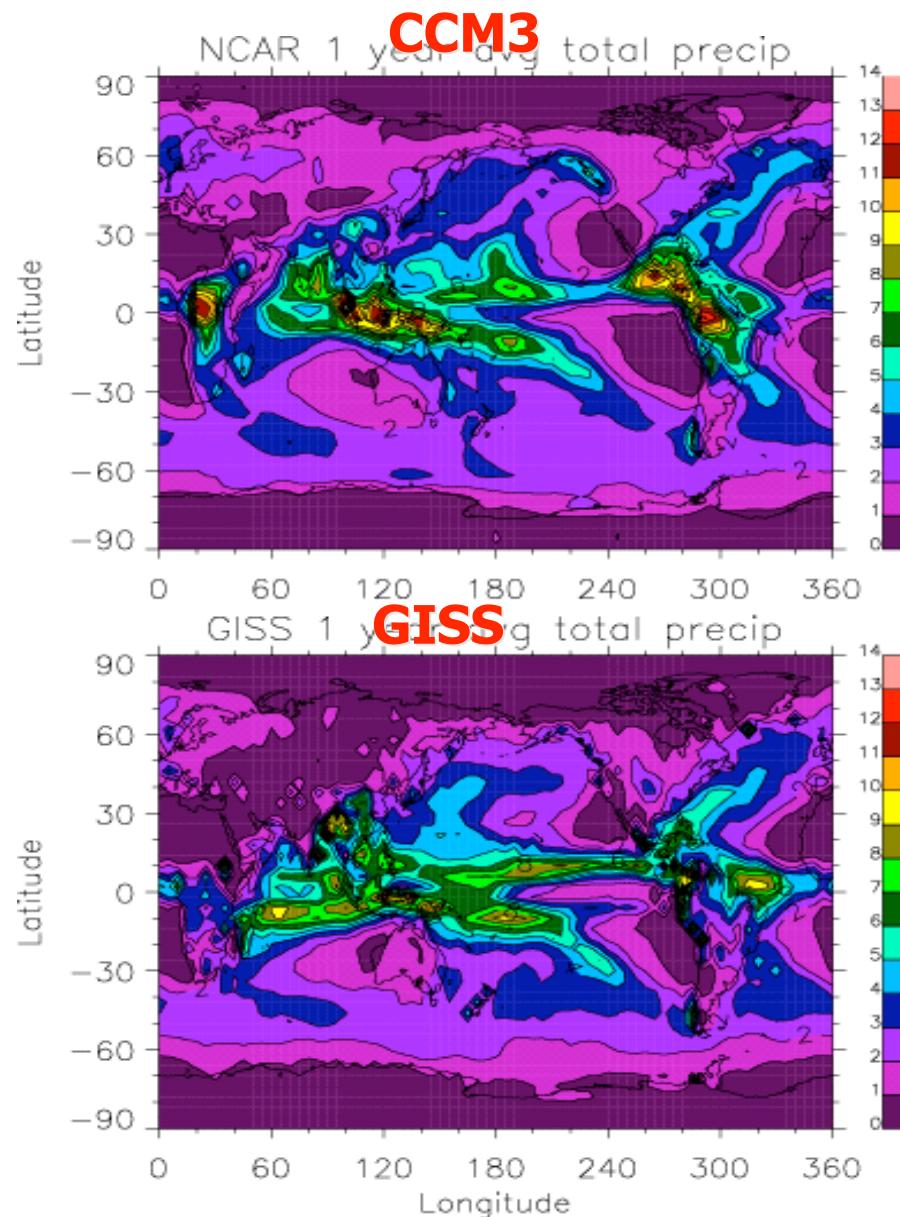
- The GMI aerosol model:
 - Driven by DAO, FVGCM, GISS met fields
 - Prognostic variables: DMS, SO_2 , SO_4 , H_2O_2 , OM, BC, mineral dust 4 bins & sea salt 4 bins (0.05-0.6, 0.6-1.2, 1.2-2.5, 2.5-10 μm radius).
 - Gas and aqueous phase sulfate production
 - Dry deposition & gravitational settling
 - Wet deposition: rain-out and washout
 - Hydroscopic growth: Gerber (1991)
 - Emissions: DMS, SO_2 , OC, BC, dust, sea salt



DAO**FVGCM****GISS**

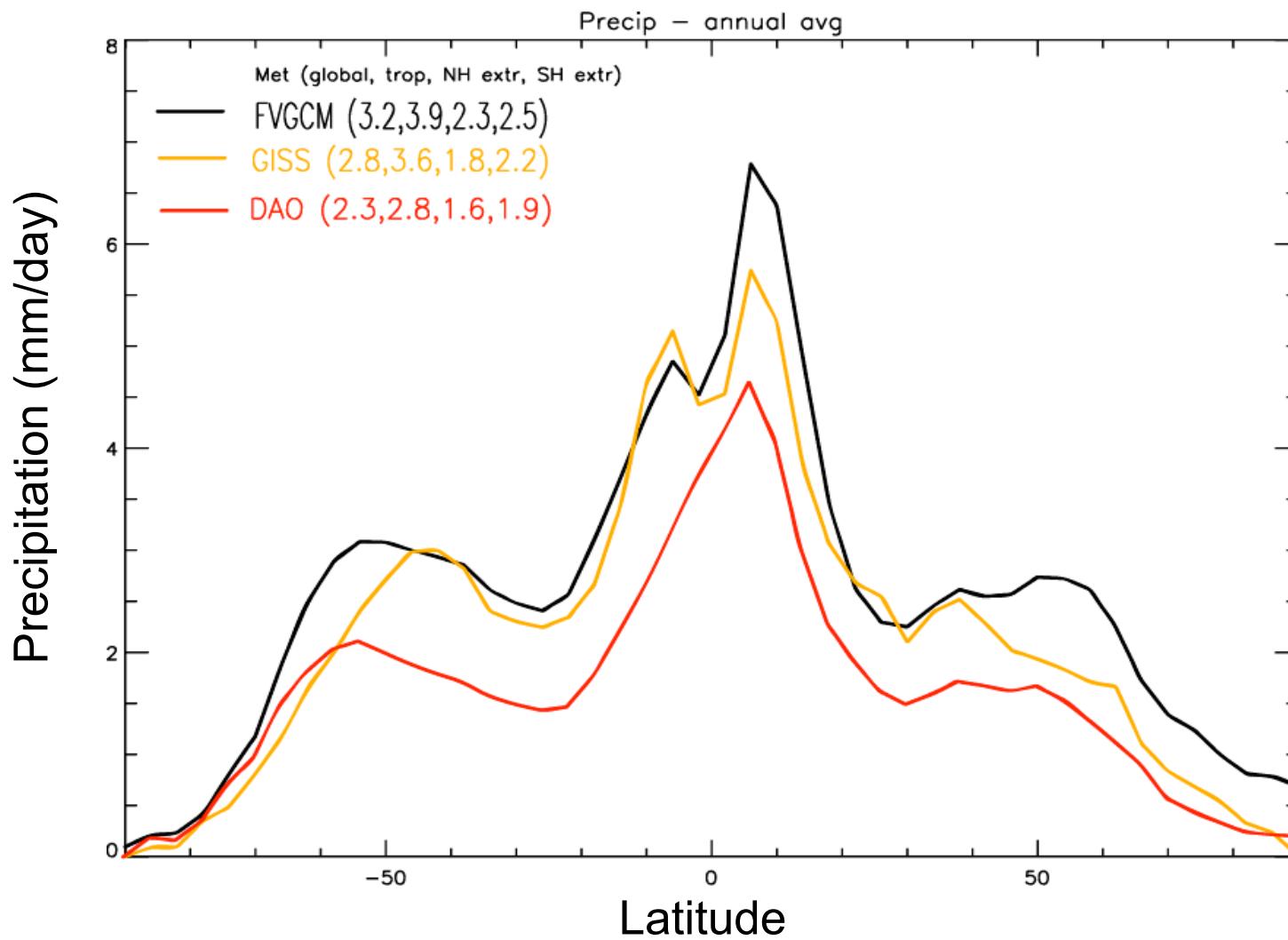
**Annual and zonal
mean SO_4**

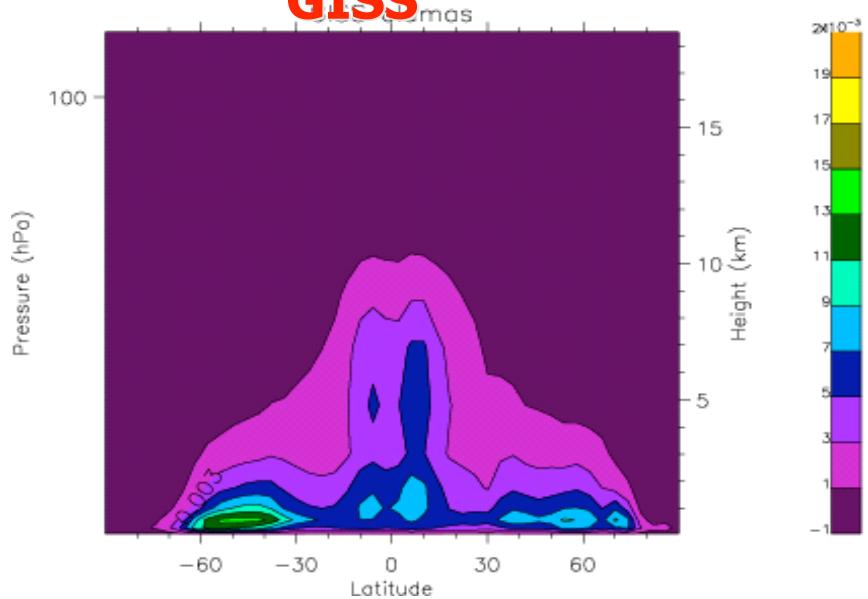
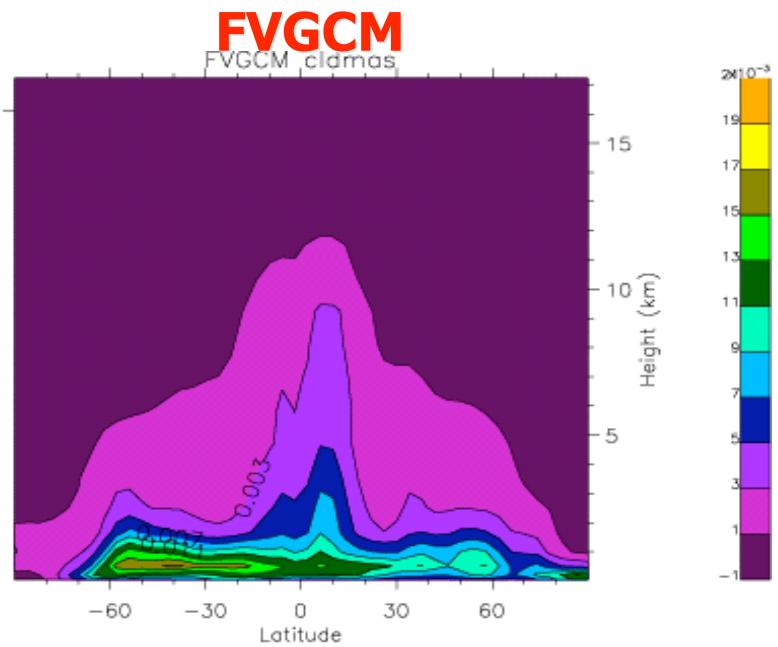
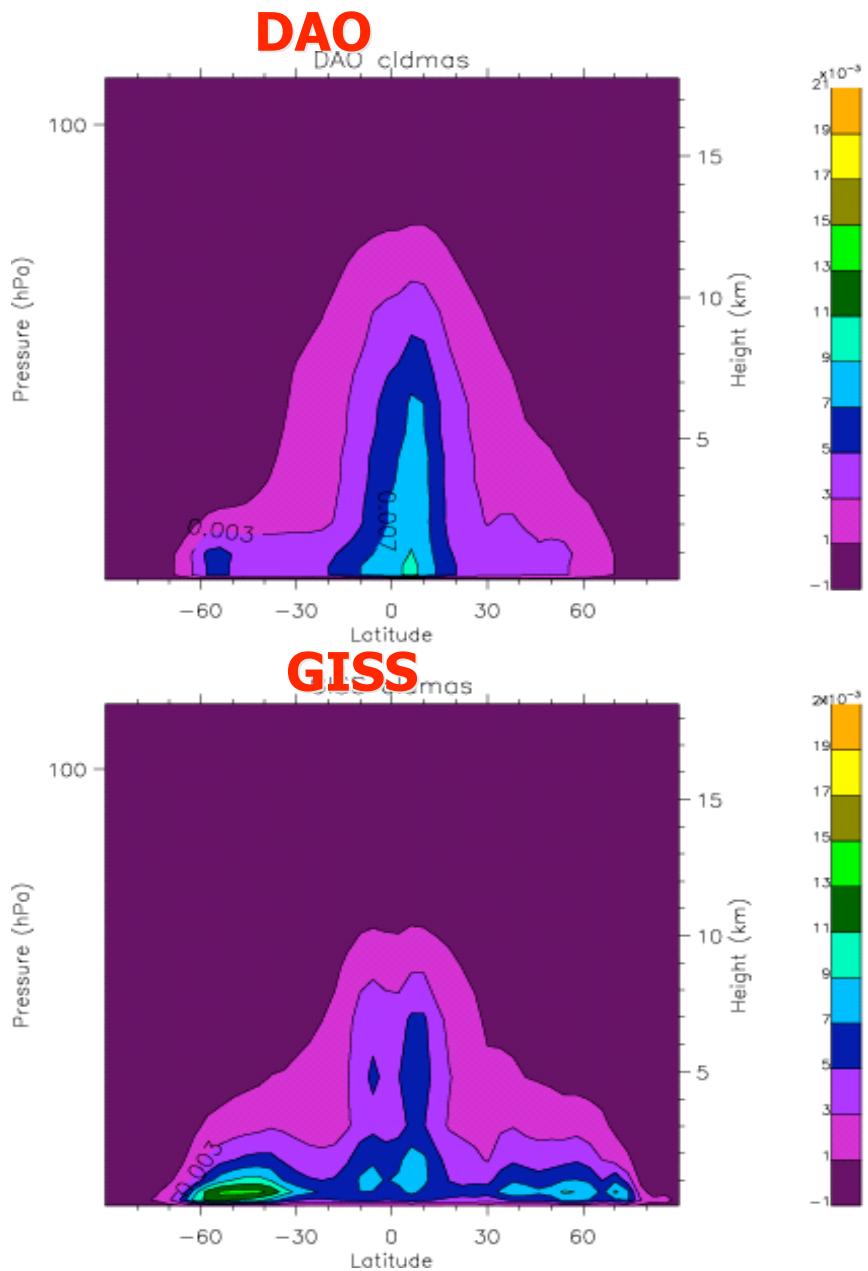
Total Precipitation at Surface



From Steve Steenrod

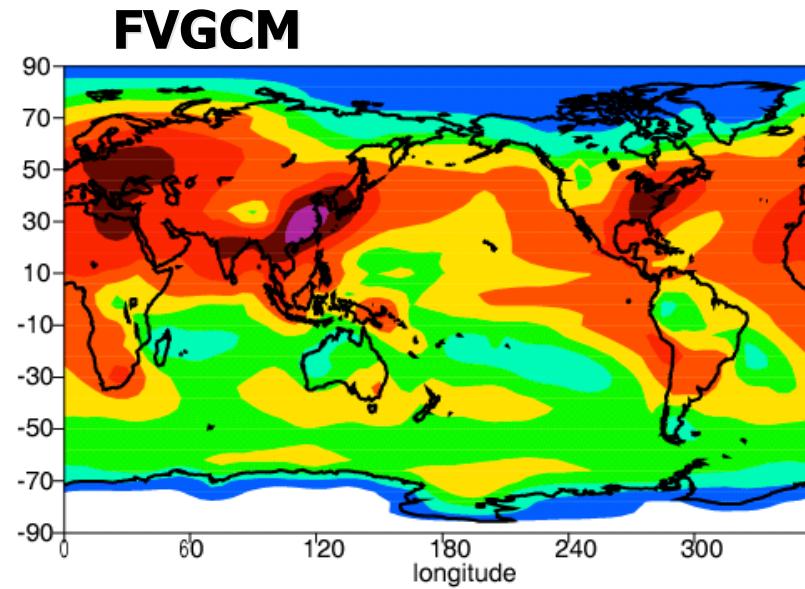
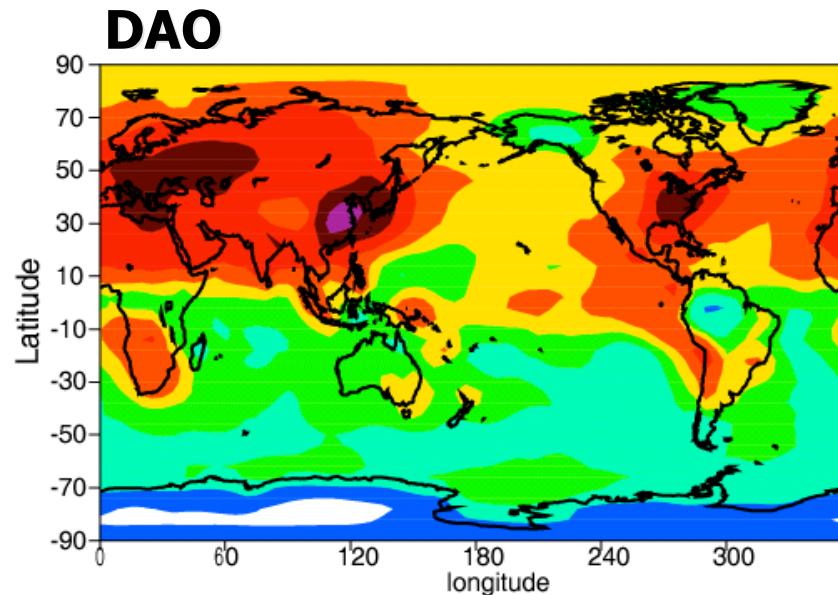
A Comparison of zonal mean precipitation at surface





Convective mass flux

From Steve Steenrod

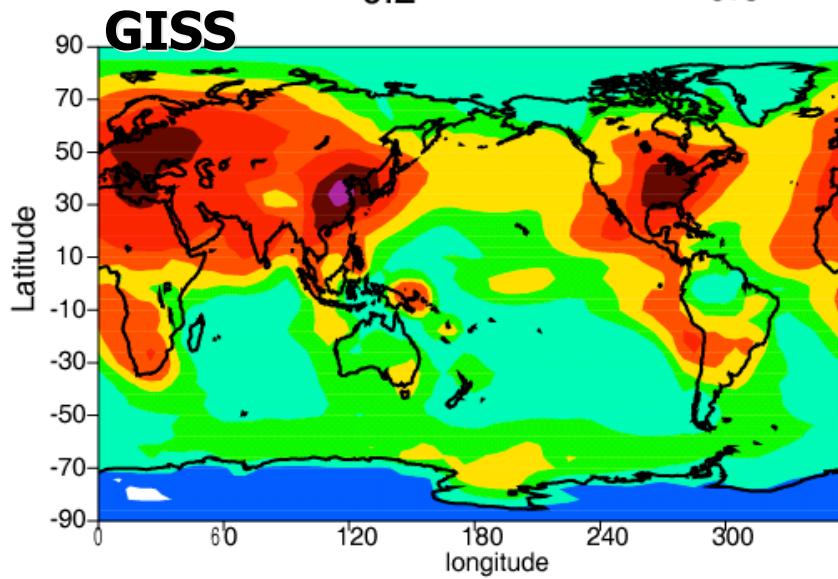


0.1
0.2
0.4

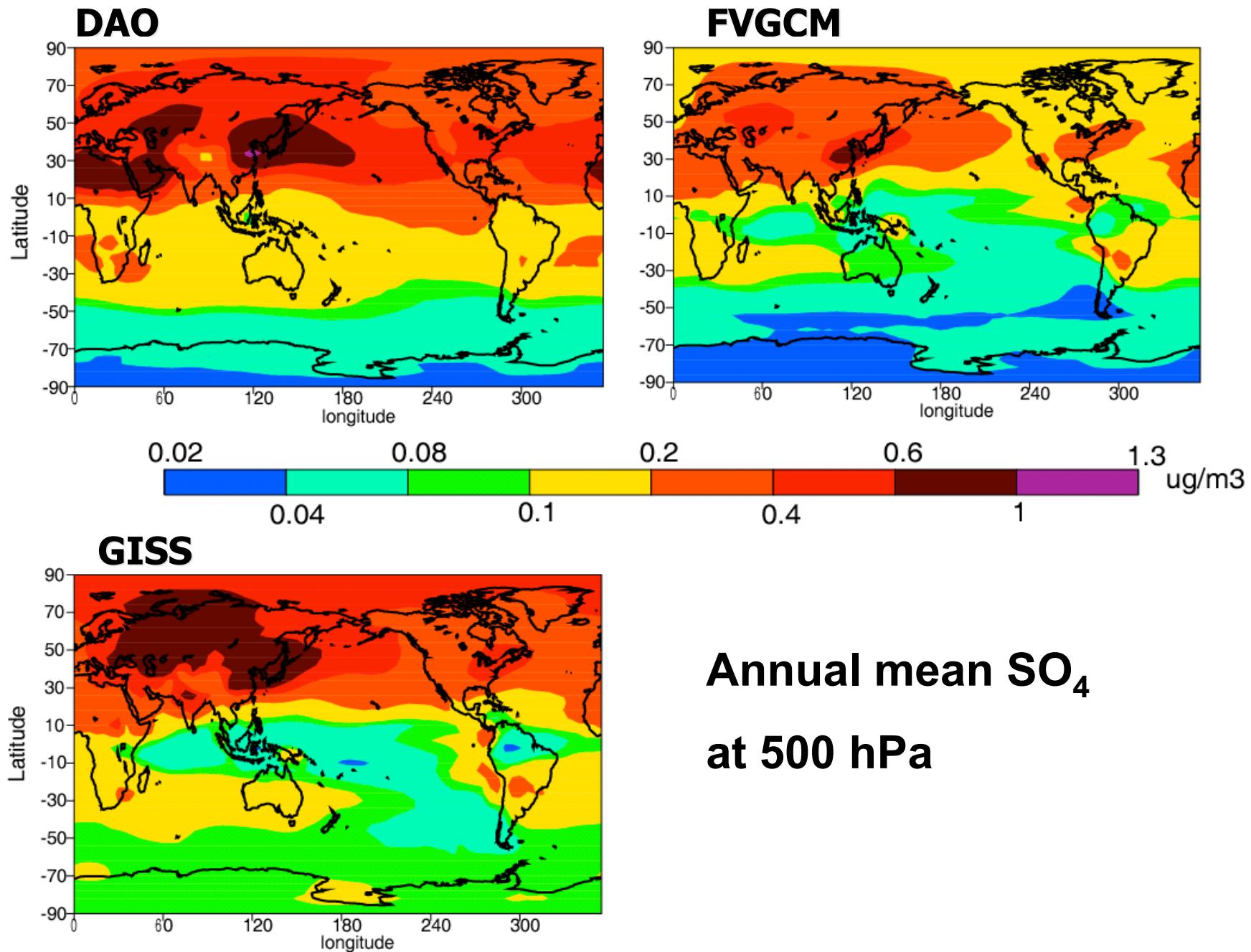
0.4
0.6

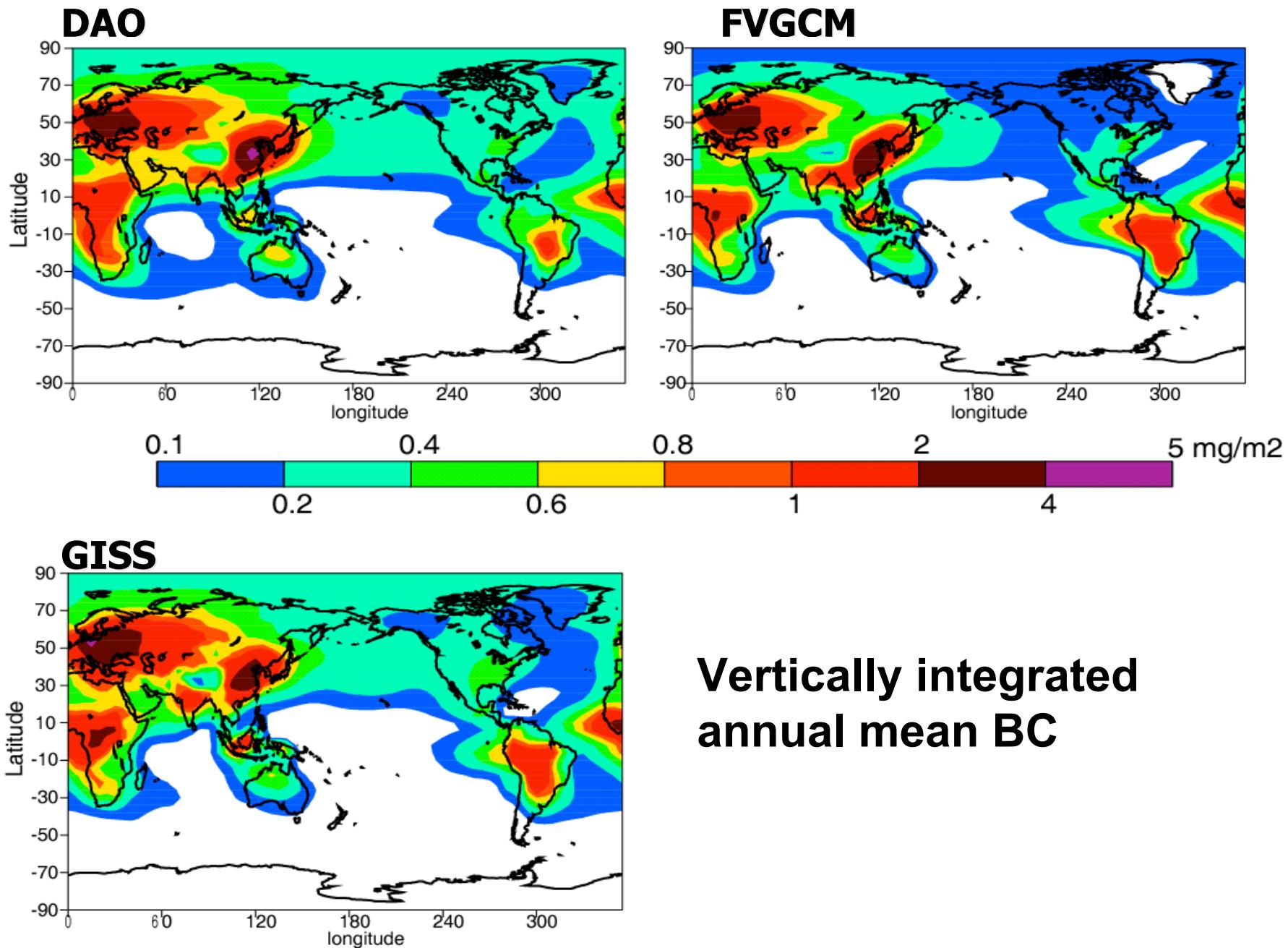
1
2
4
8

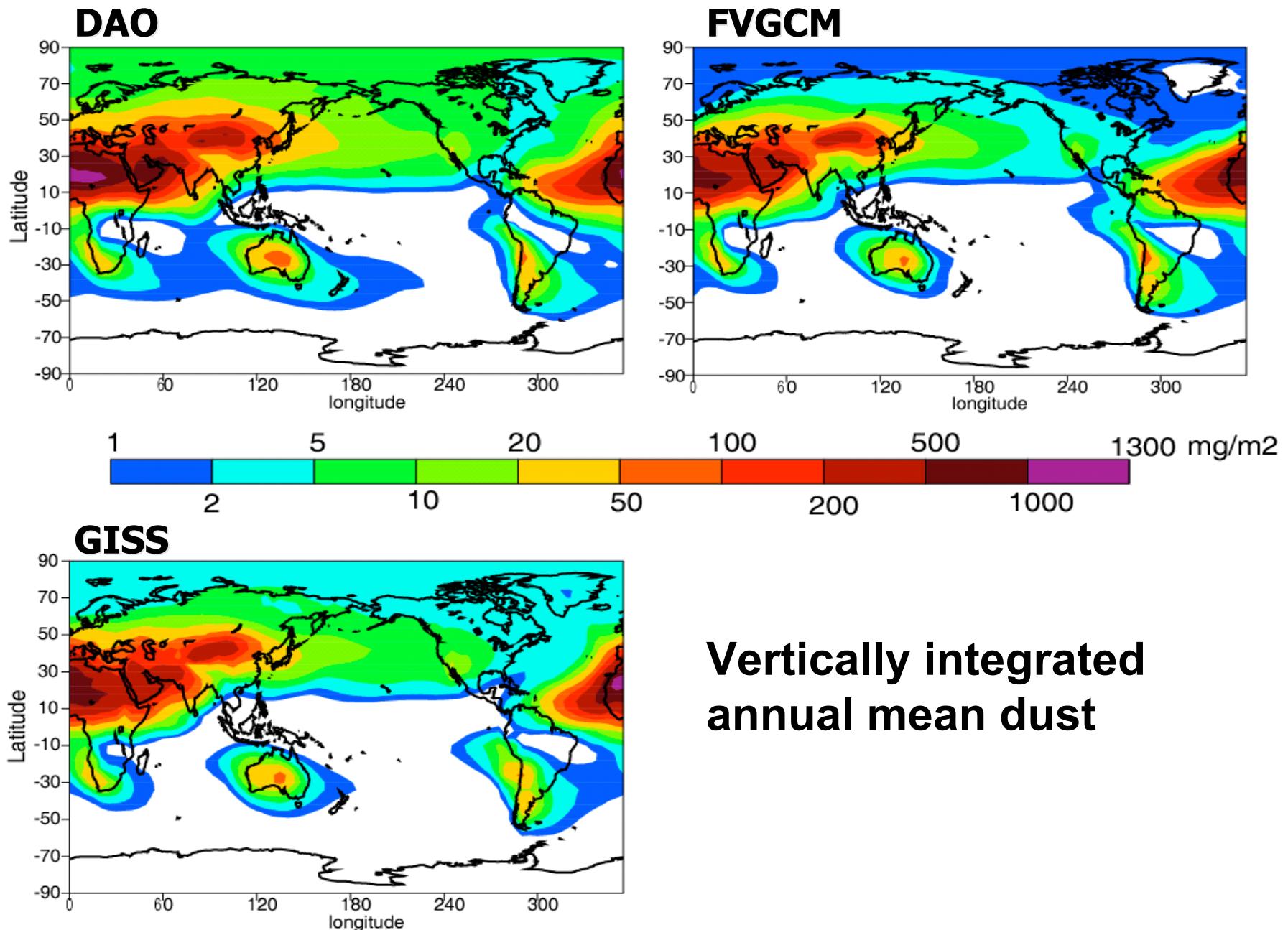
12 $\mu\text{g}/\text{m}^3$

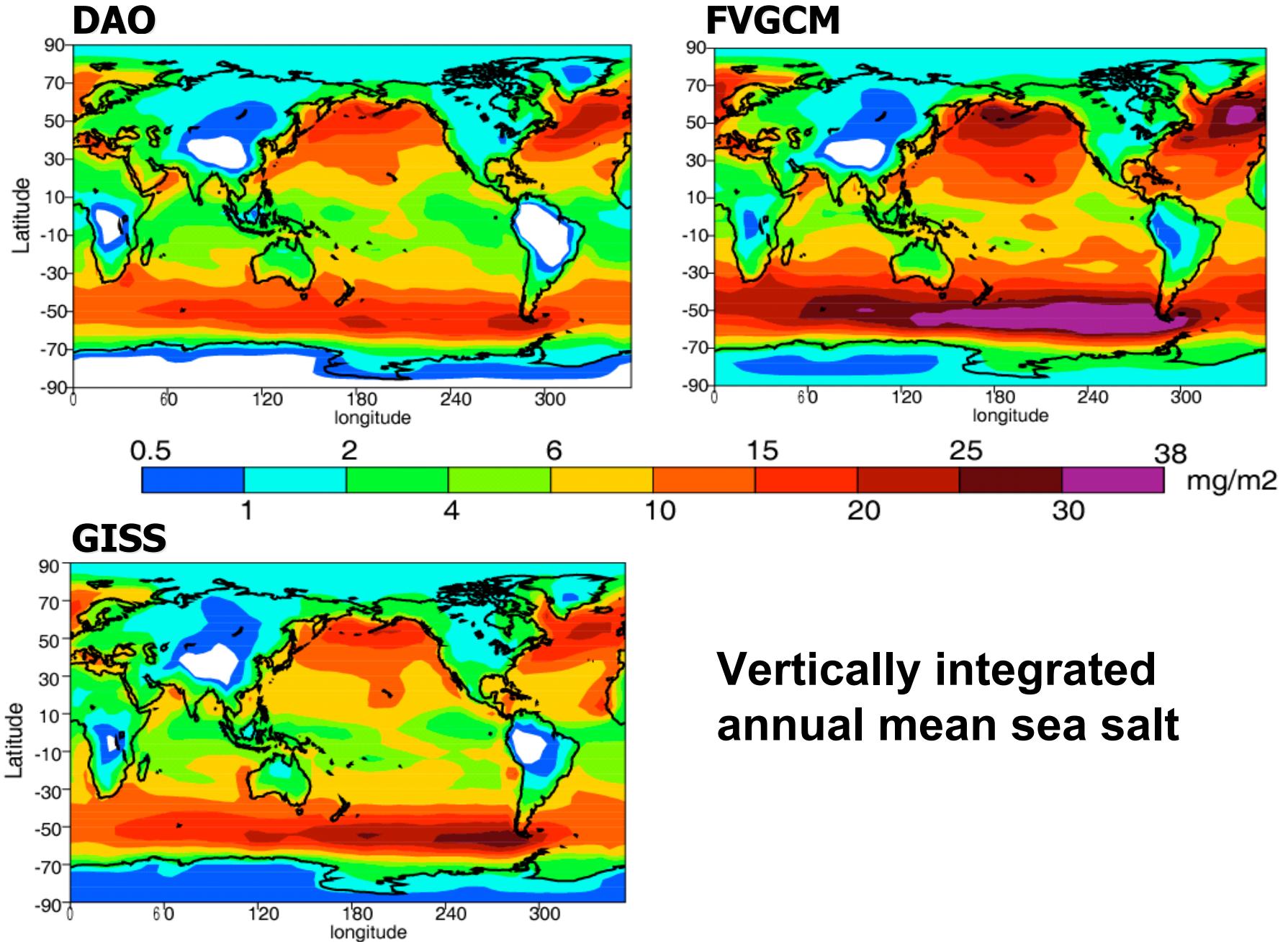


**Annual mean SO_4 at
surface**







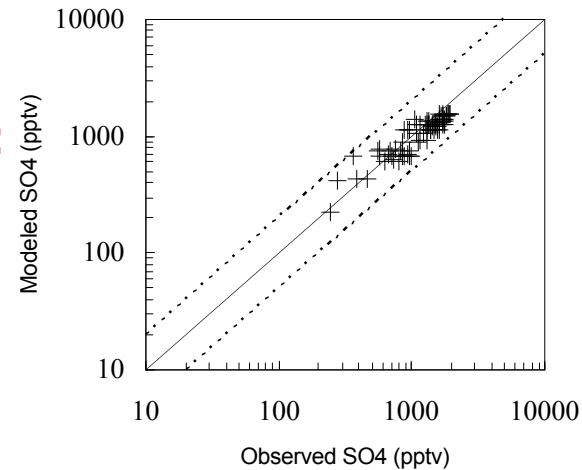


Comparison of modeled SO₄ with EMEFS data (N. America)

DAO

average bias:
-149 pptv

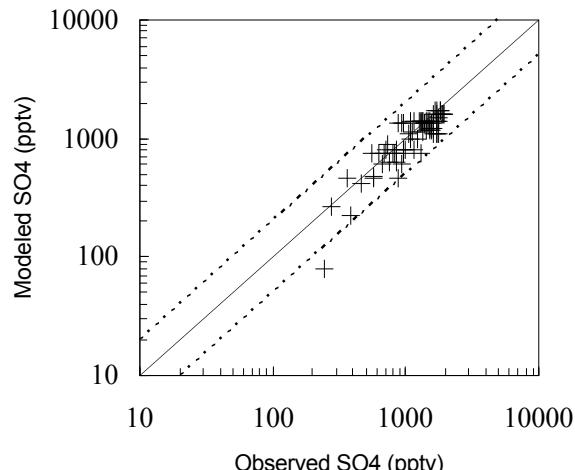
relative bias:
-8%



FVGCM

average bias:
-115 pptv

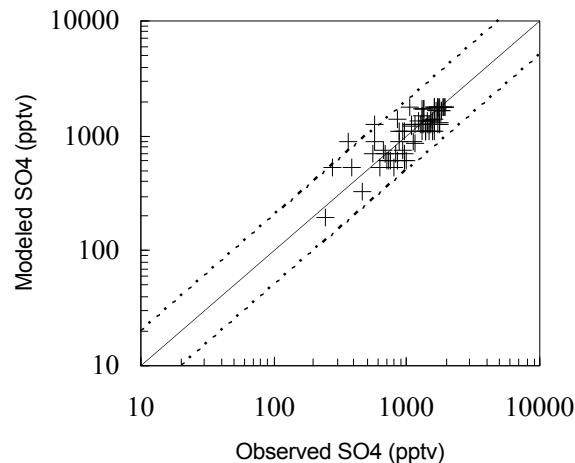
relative bias:
-8%



GISS

average bias:
-46 pptv

relative bias:
0.9%

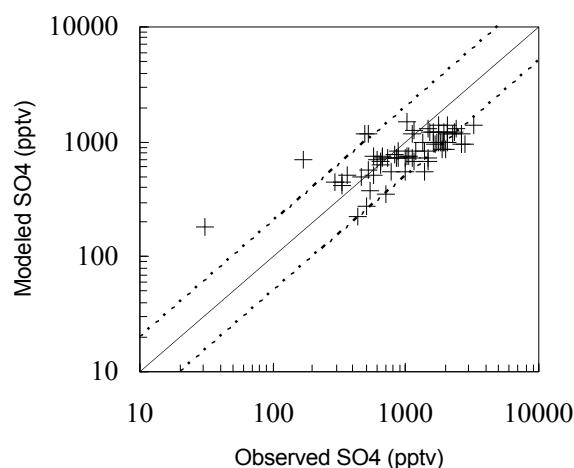


Comparison of modeled SO₄ with EMEP data (Europe)

DAO

average bias:
-412 pptv

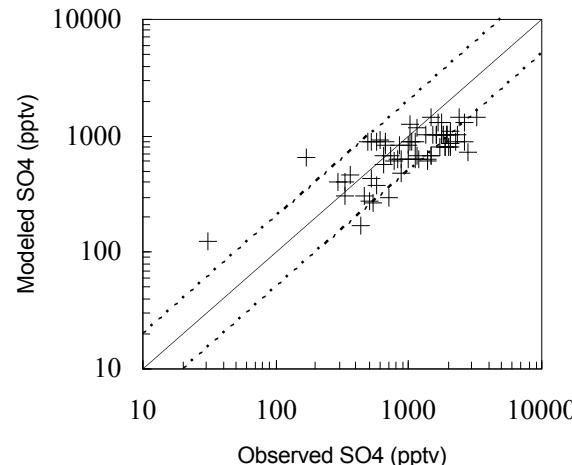
relative bias:
-8%



FVGCM

average bias:
-472 pptv

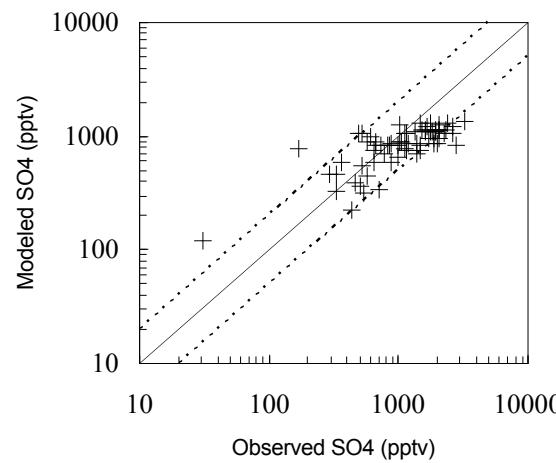
relative bias:
-17%



GISS

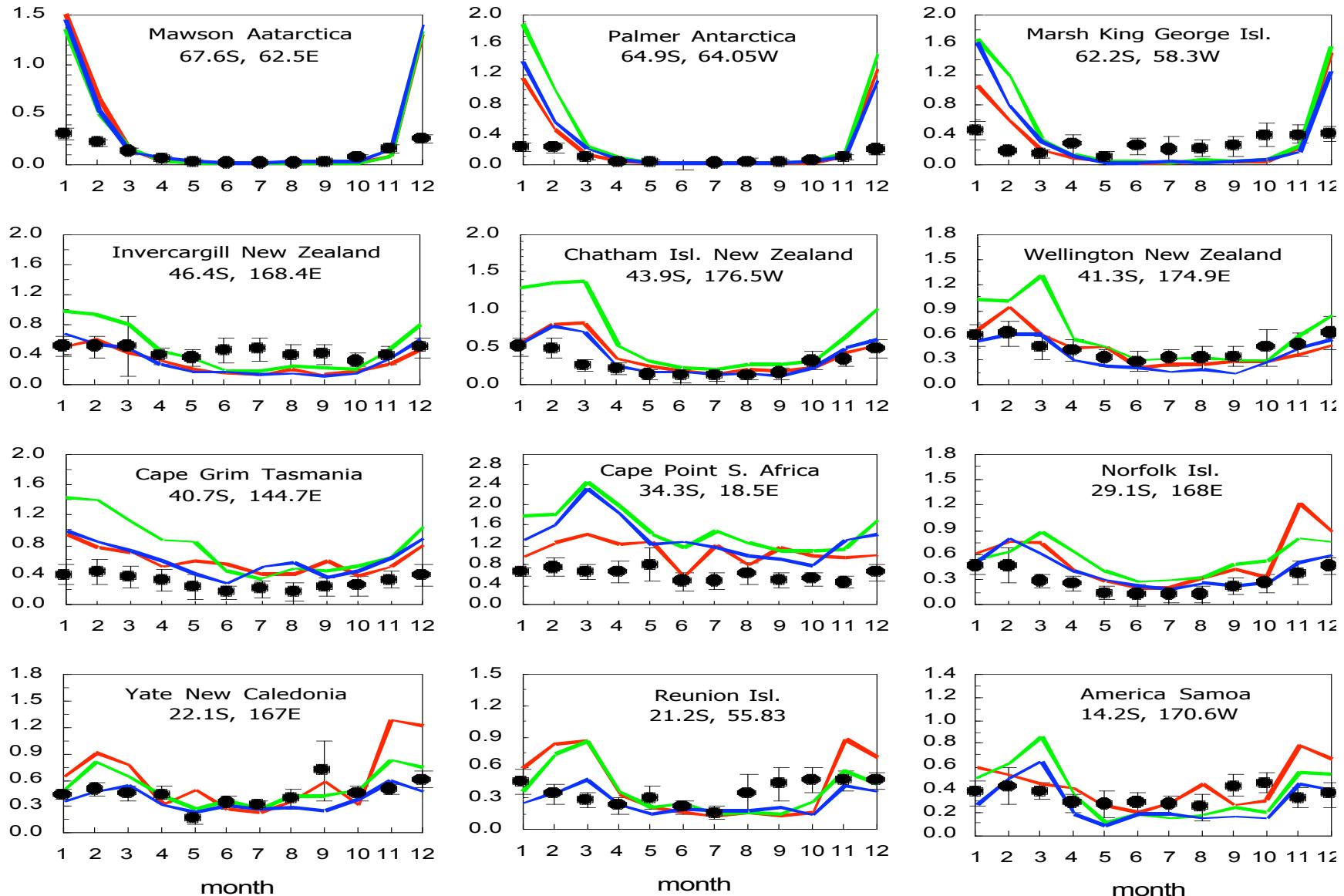
average bias:
-396 pptv

relative bias:
-8%

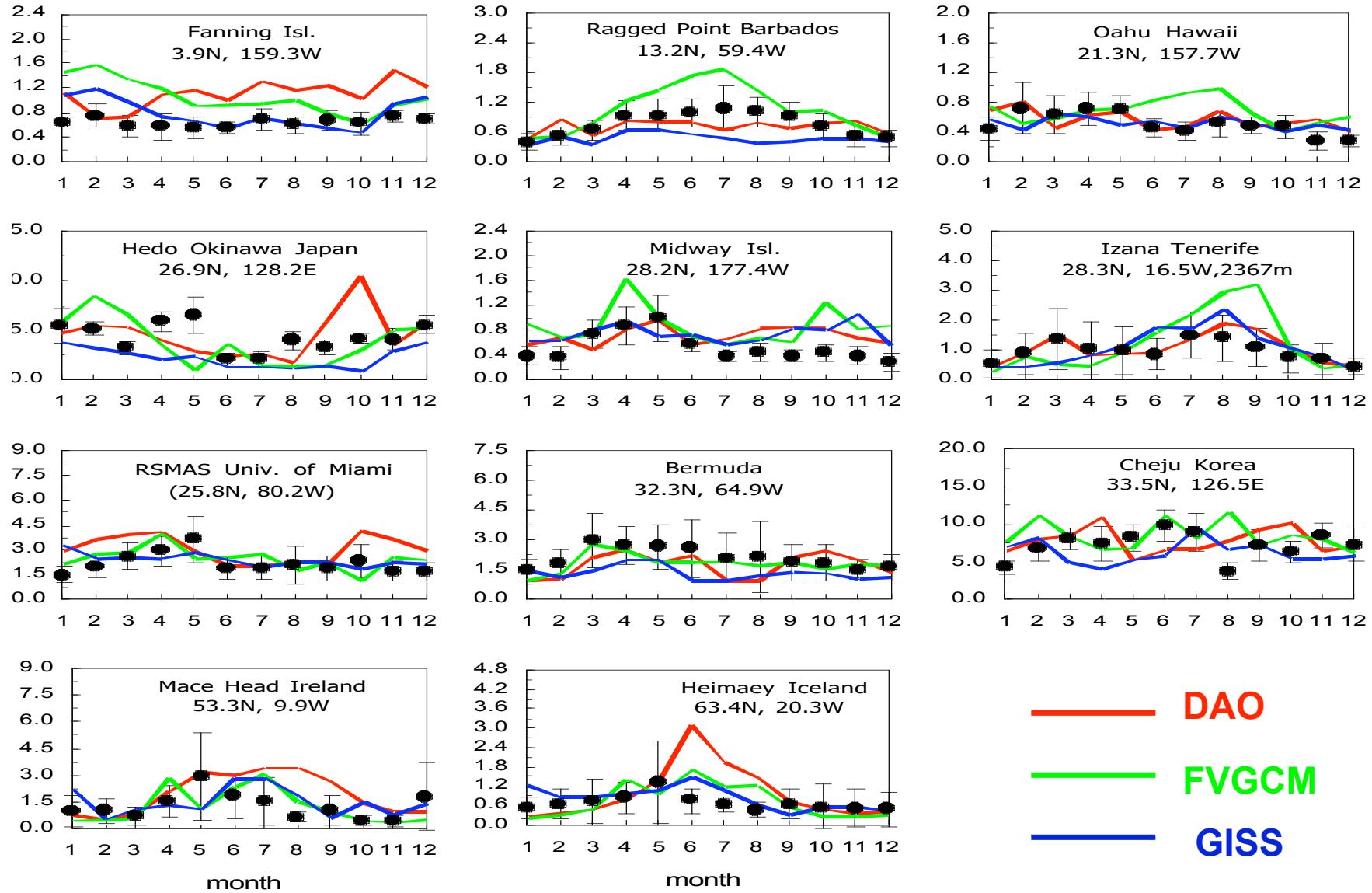


Comparison of modeled SO_4 with observations at oceanic sites (SH)

— DAO
— FVGCM
— GISS



Comparison of modeled SO₄ with observations at oceanic sites (NH)



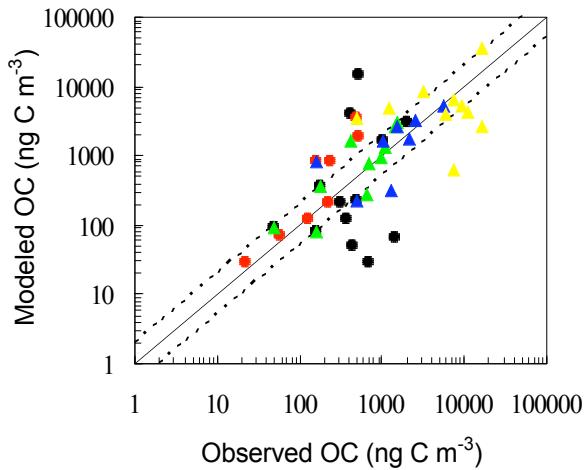
— DAO
— FVGCM
— GISS

Comparison of modeled OC with field observations at surface

DAO

average bias:
0.53 ug/m³

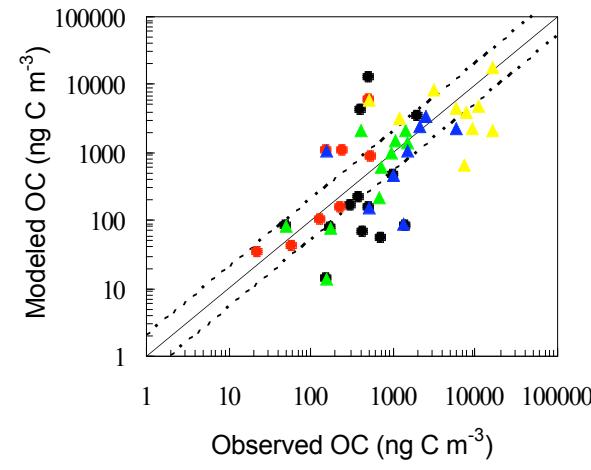
relative bias:
157 %



FVGCM

average bias:
-0.44 ug/m³

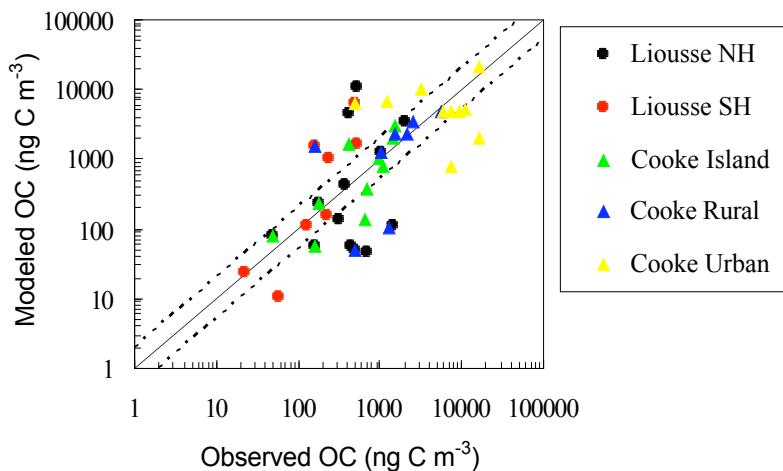
relative bias:
85 %



GISS

average bias:
0.74 ug/m³

relative bias:
208 %

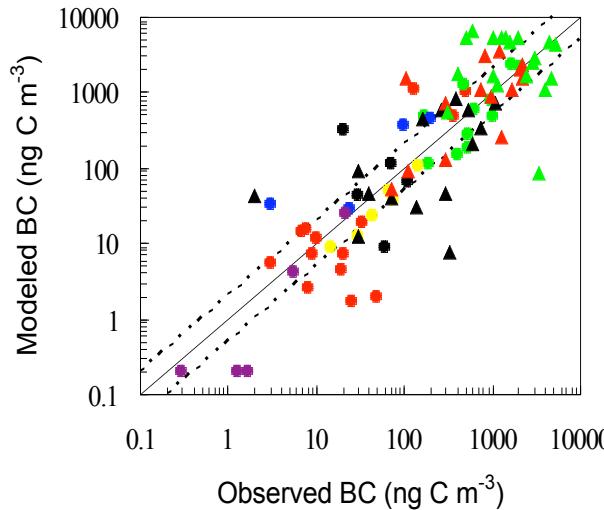


Comparison of modeled BC with field observations at surface

DAO

average bias:
0.057 ug/m³

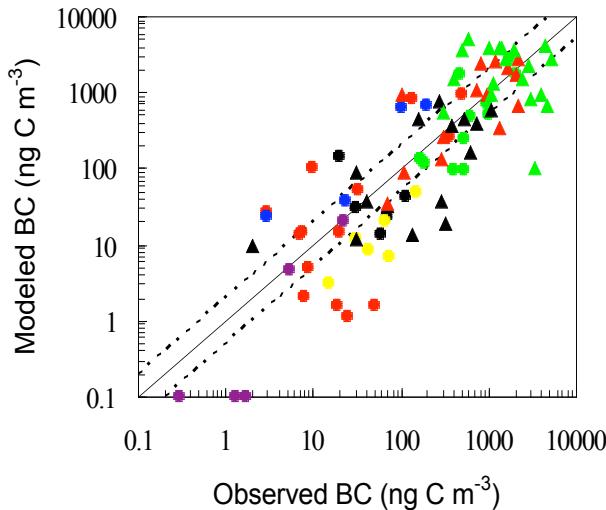
relative bias:
113 %



FVGCM

average bias:
-0.17 ug/m³

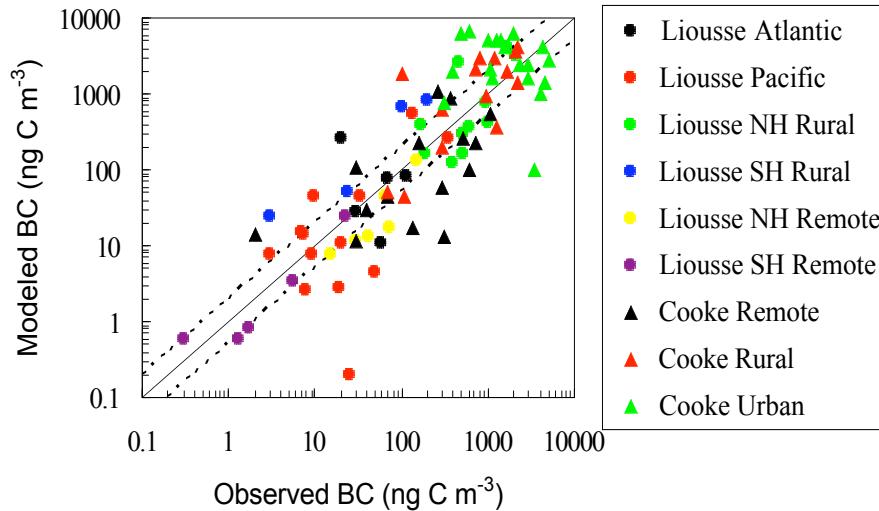
relative bias:
70 %



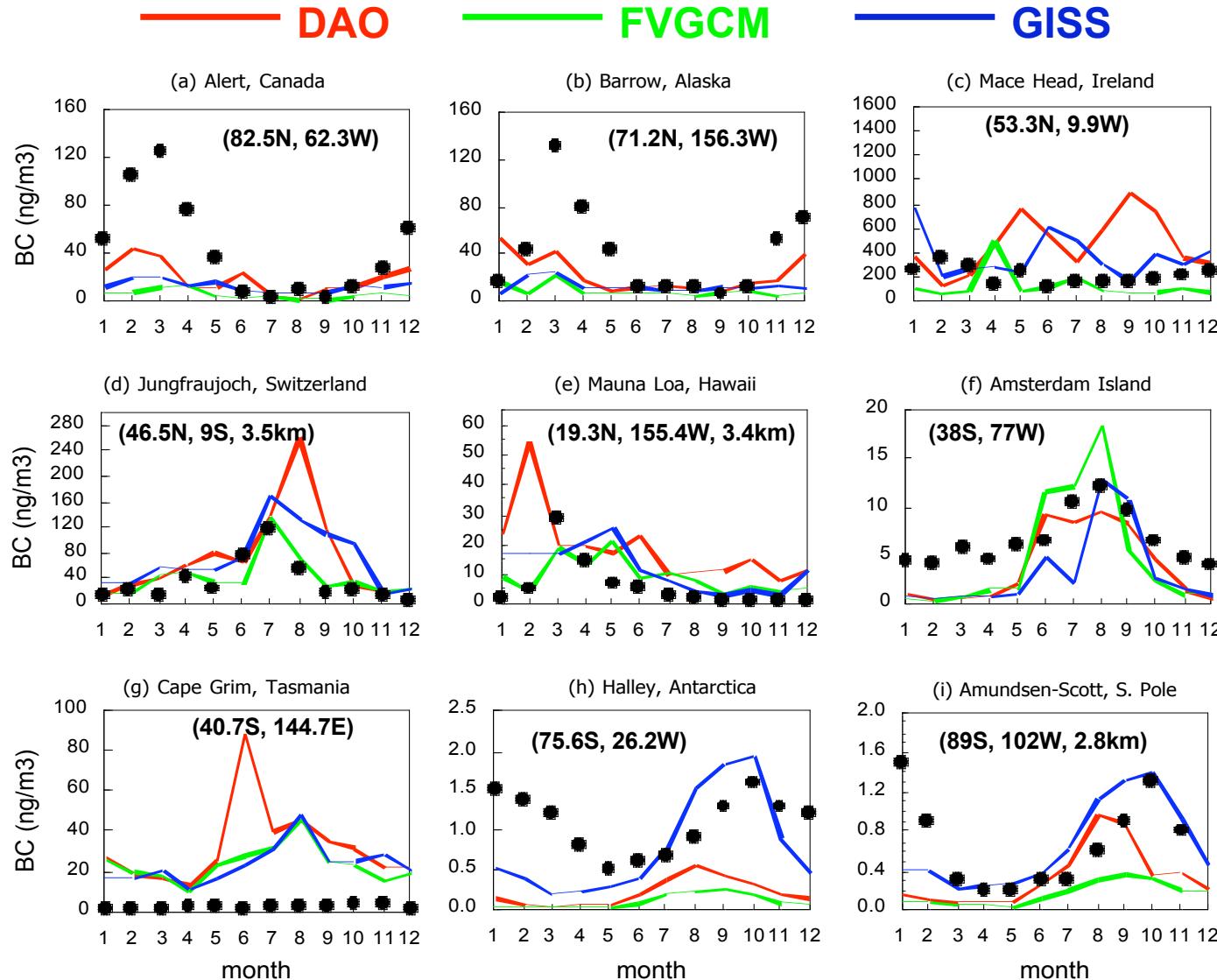
GISS

average bias:
0.091 ug/m³

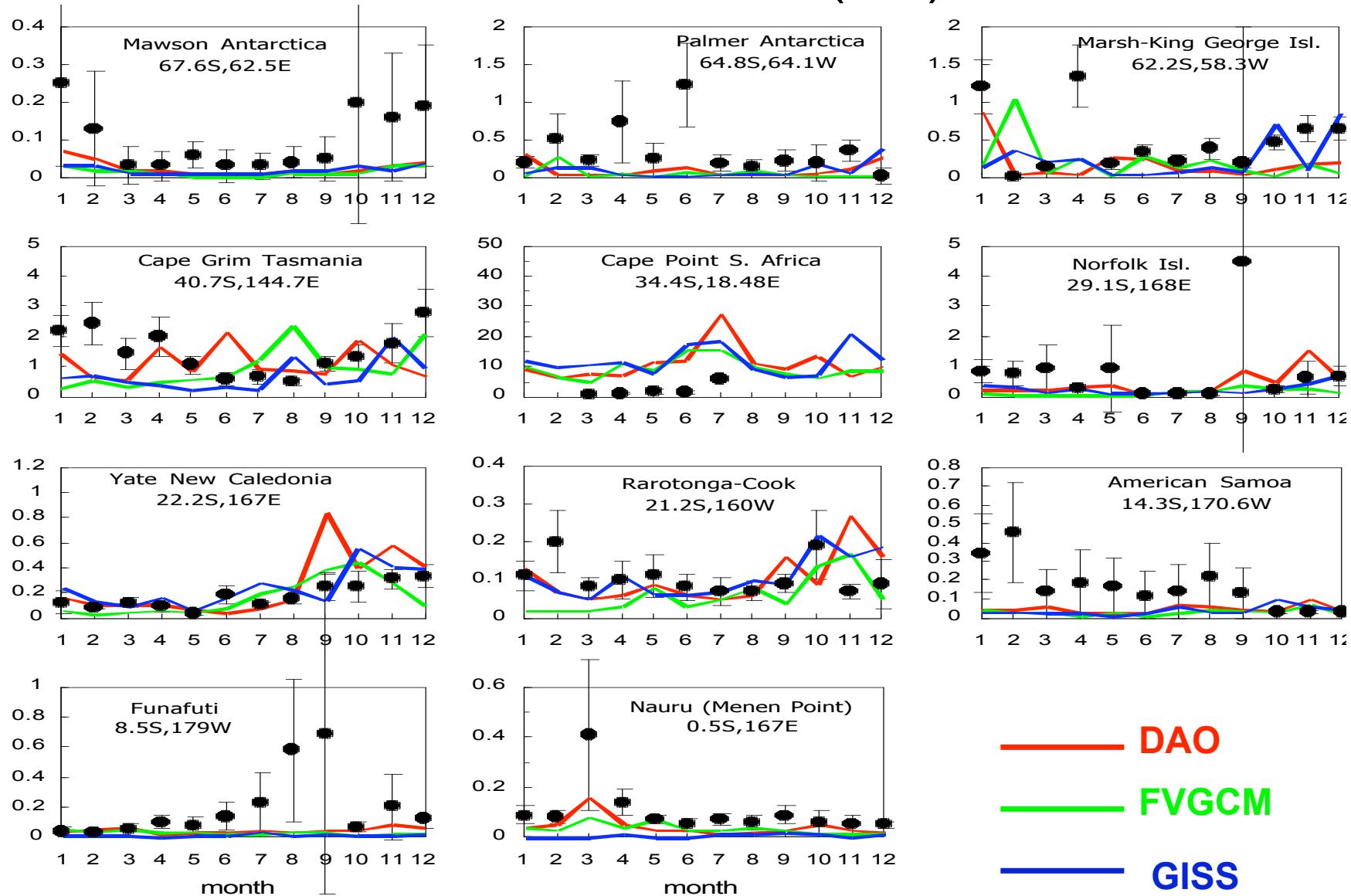
relative bias:
104 %



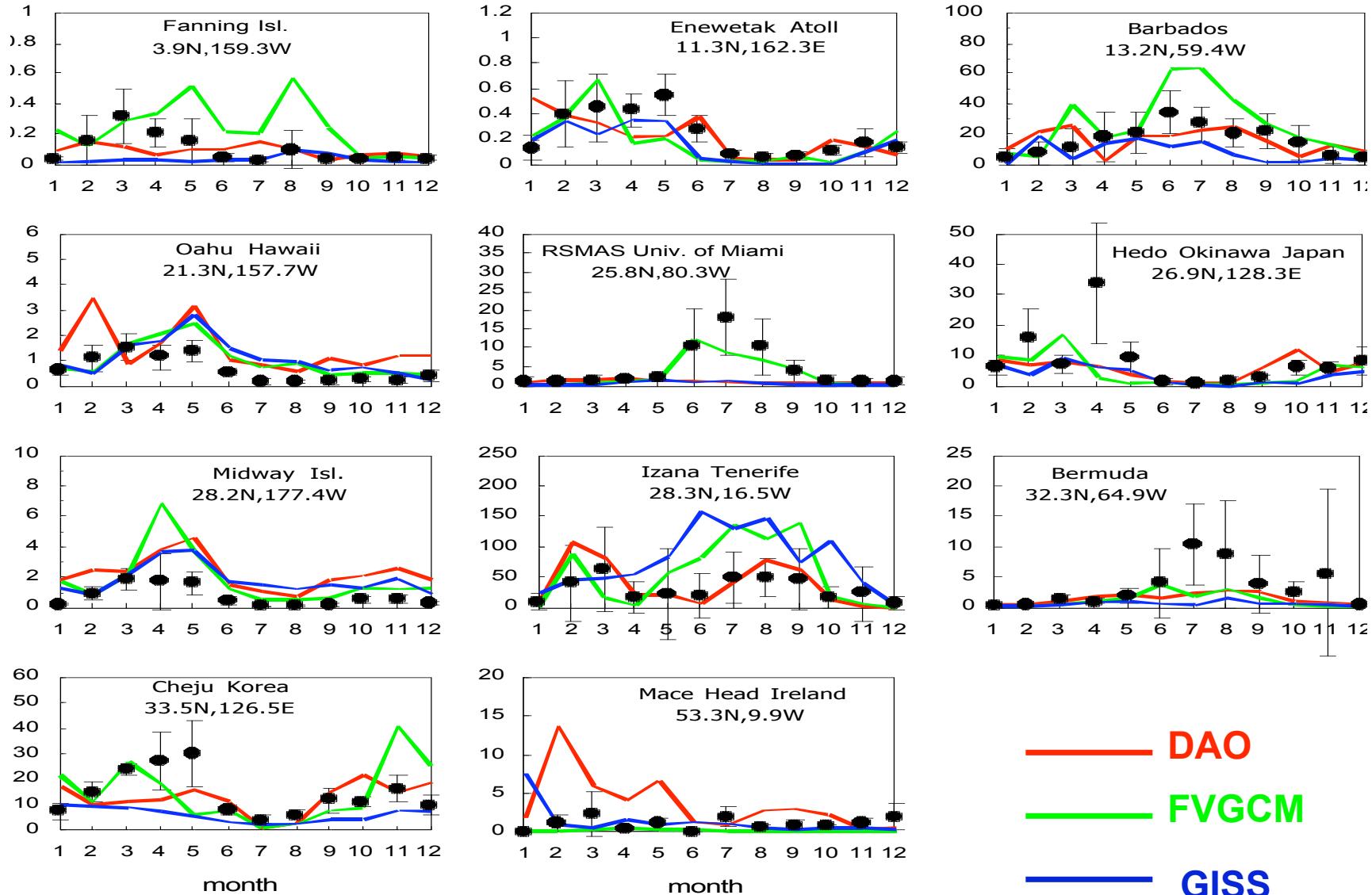
Comparison of modeled BC with observations at surface



Comparison of modeled dust with observations at oceanic sites (SH)

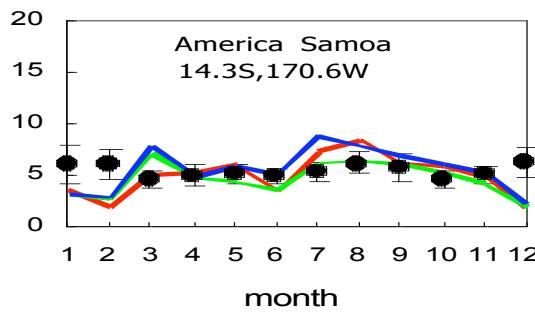
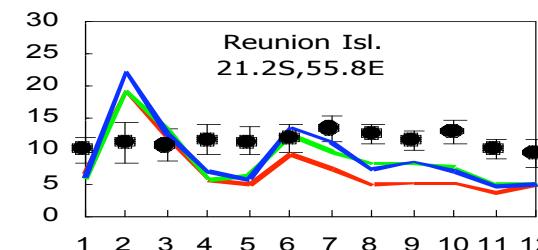
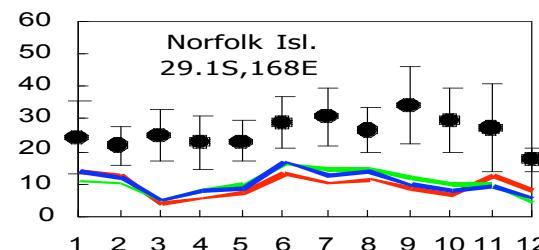
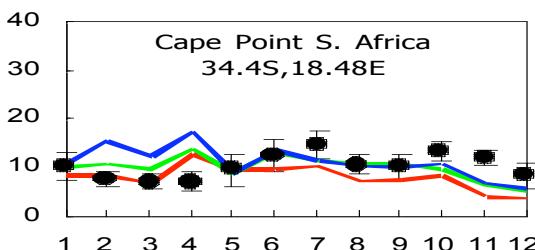
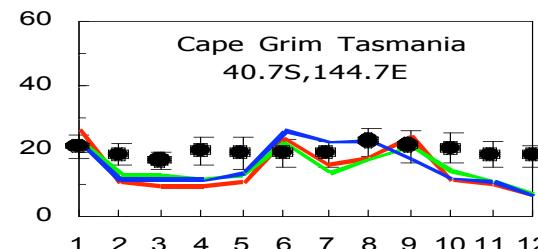
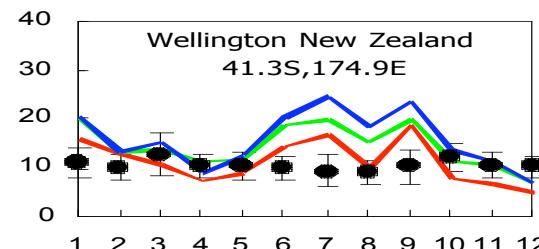
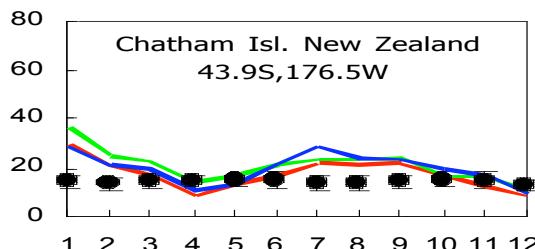
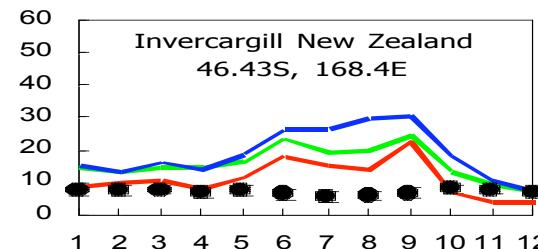
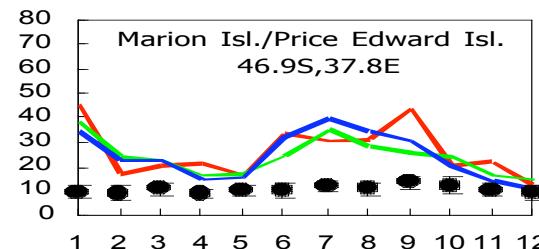
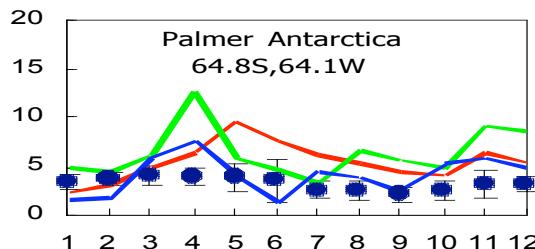


Comparison of modeled dust with observations at oceanic sites (NH)



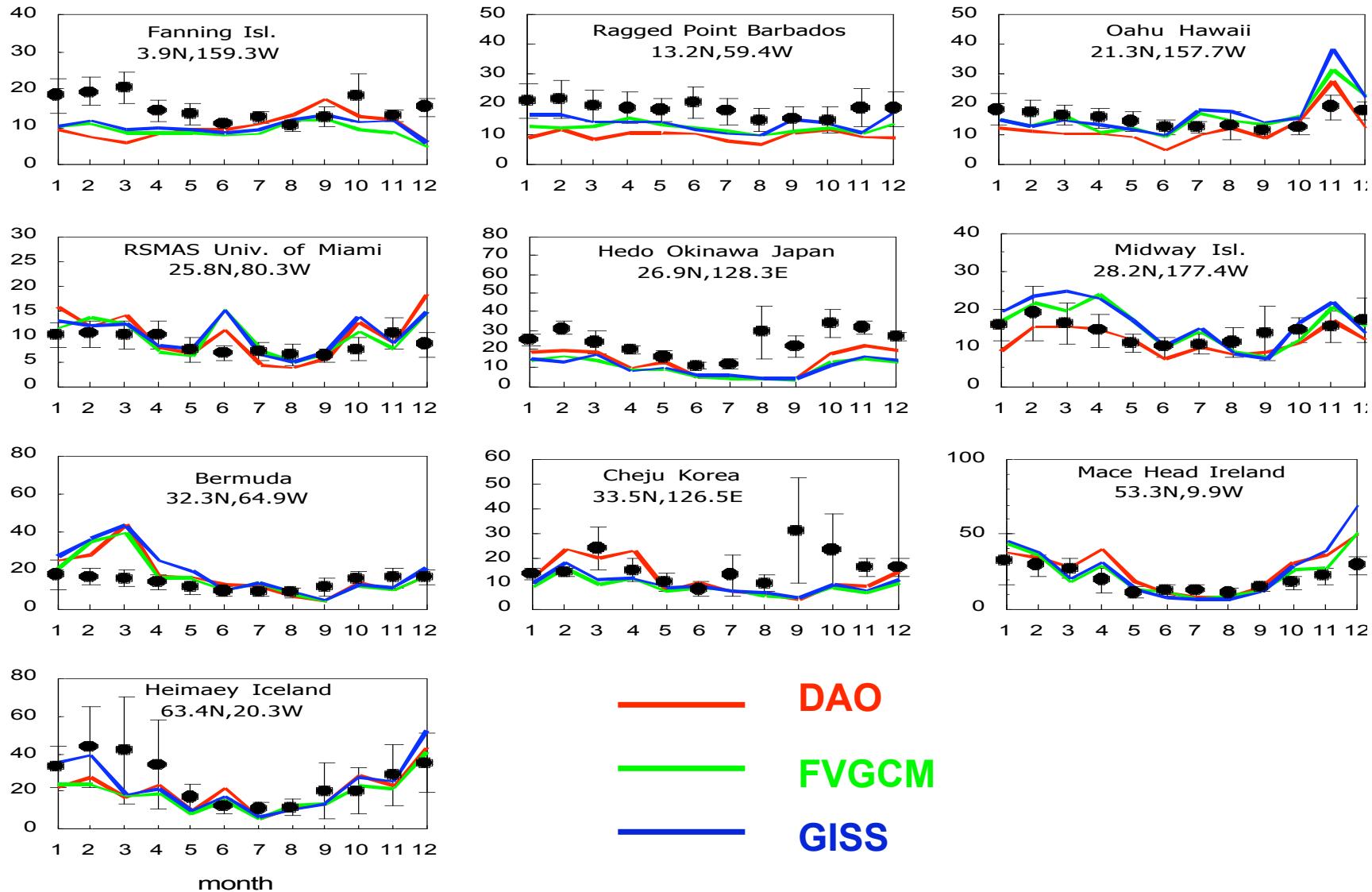
— DAO
— FVGCM
— GISS

Comparison of modeled sea salt with observations at oceanic sites (SH)



— DAO
— FVGCM
— GISS

Comparison of modeled sea salt with observations at oceanic sites (NH)

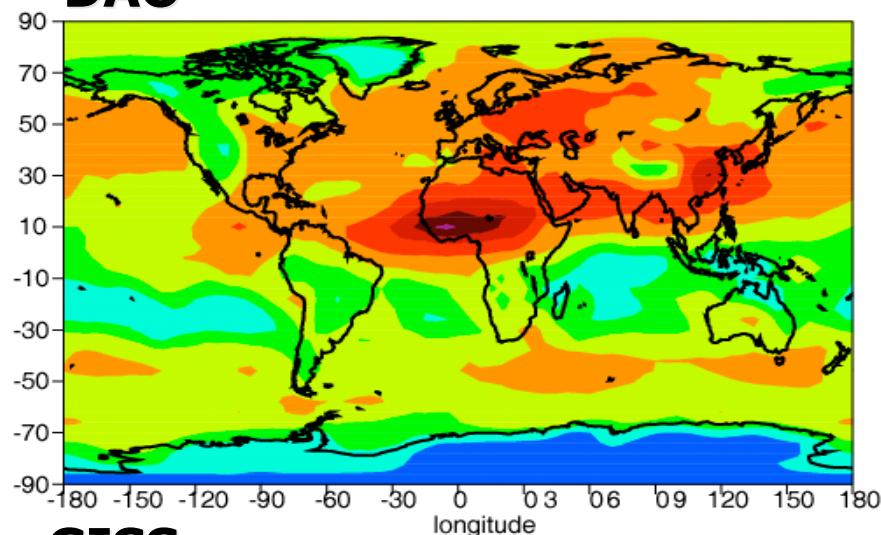


Aerosol optical depth & direct radiative forcing

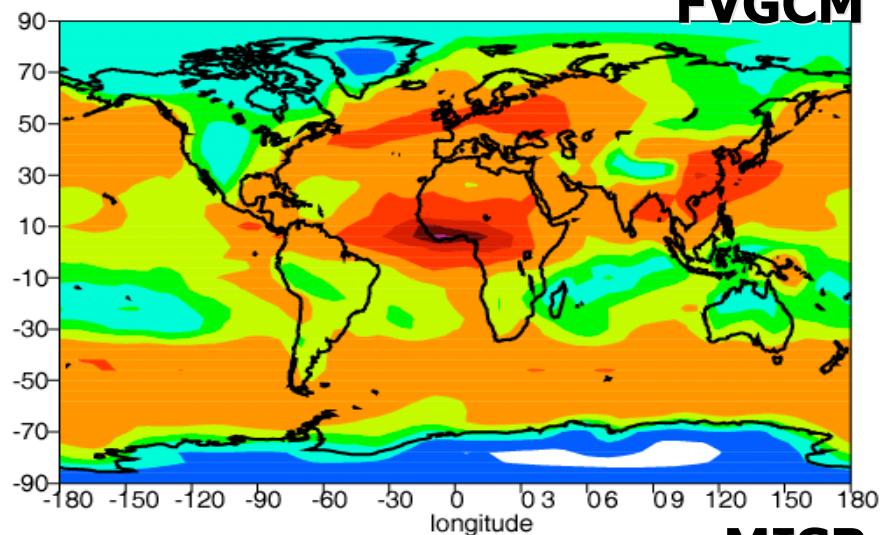
- Present-day and pre-industrial GMI aerosol runs (DAO, FVGCM, GISS);
- Meteorological data at every 6-hr (T, P, qv);
- Aerosol optical properties calculated from Mie theory assuming fossil fuel SO_4 /OM/BC mixed, biomass burning OM/BC hydrophilic & mixed, RH-dependent properties for SO_4 and sea salt.
- Maximum-random cloud overlap scheme (for all sky)
- Radiative transfer model: SW from Keith Grant (1998)

Aerosol optical depth (January)

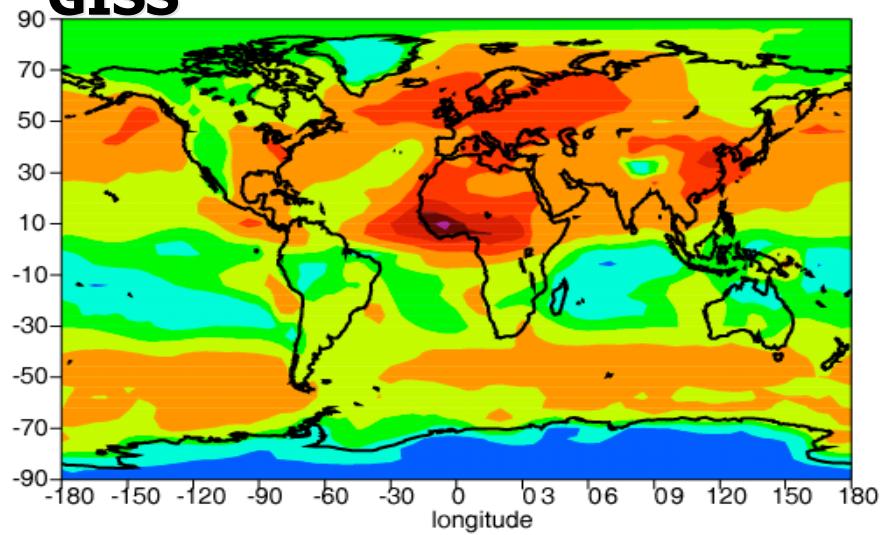
DAO



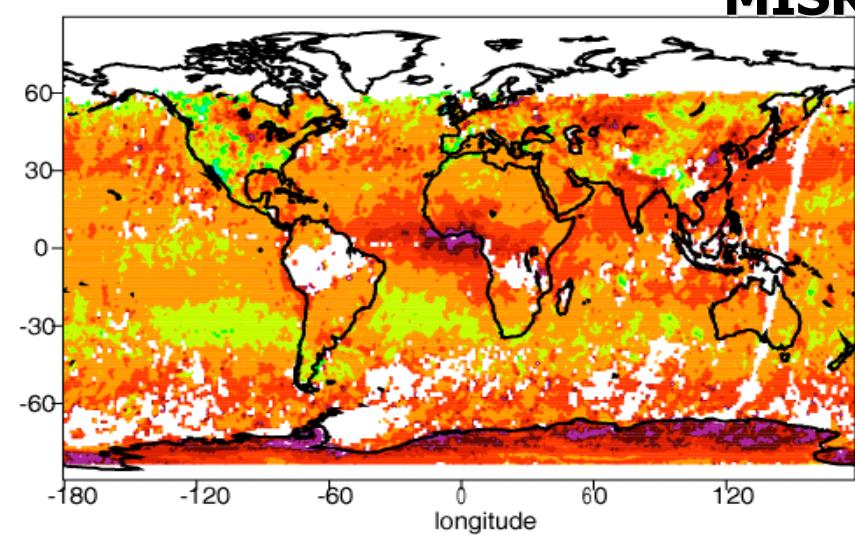
FVGCM



GISS



MISR



0.01



0.04



0.1



0.4

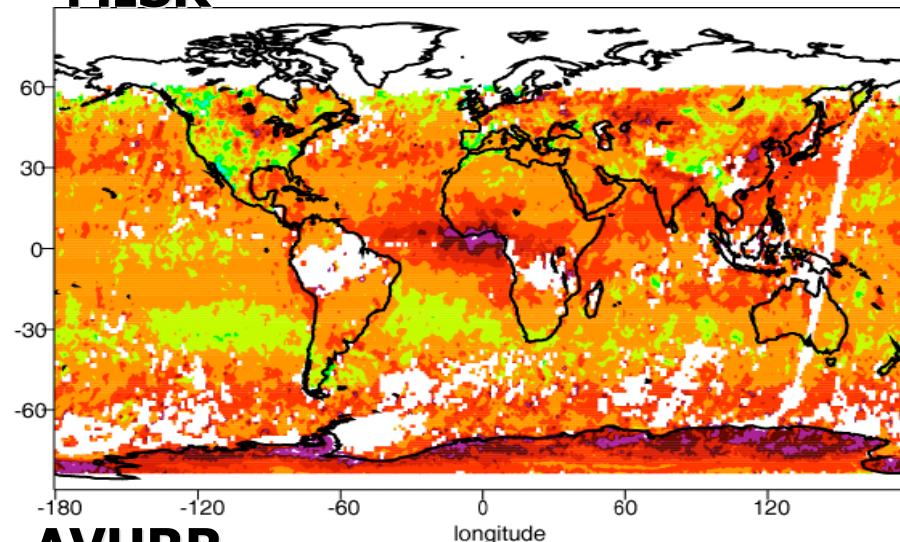


0.8

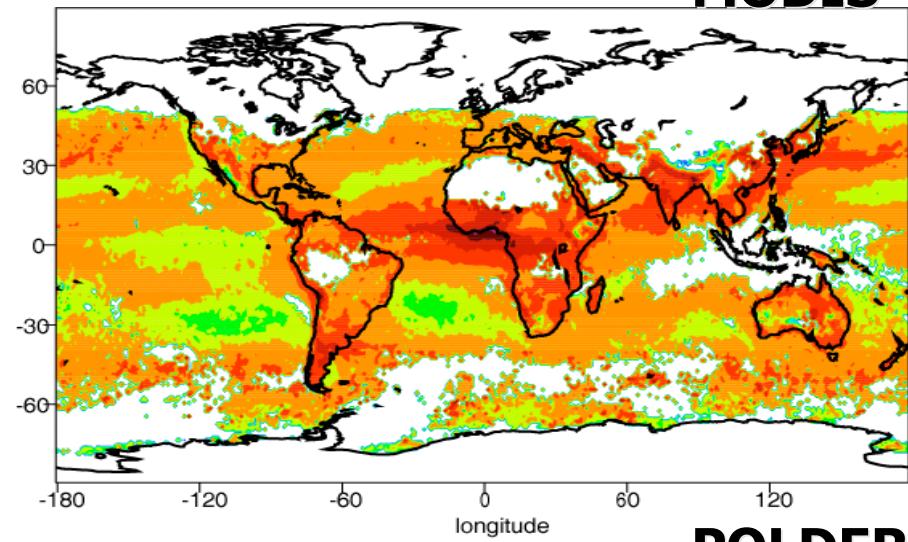


Aerosol optical depth from satellite (Jan.)

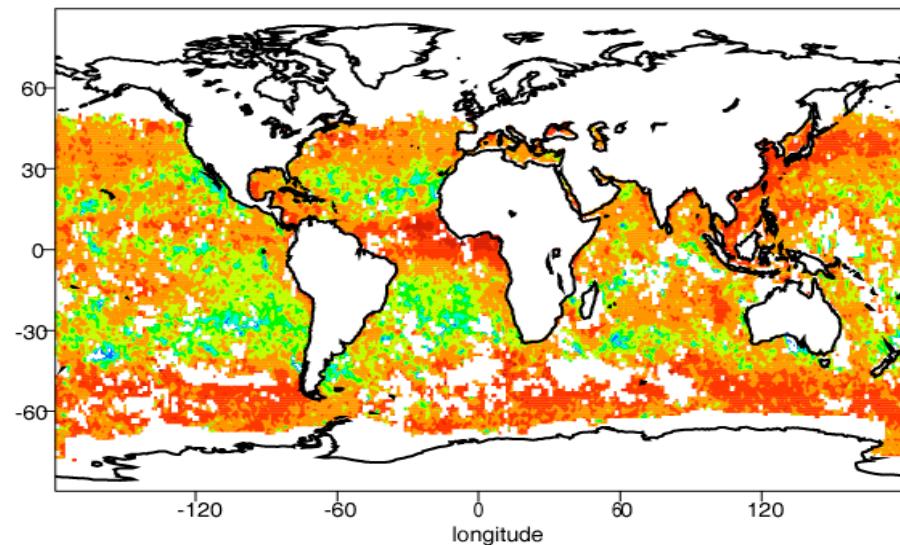
MISR



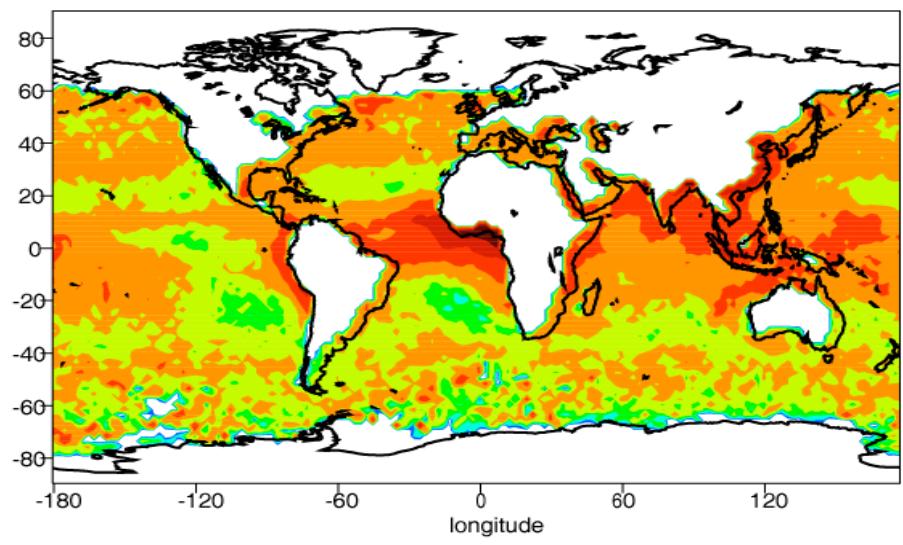
MODIS



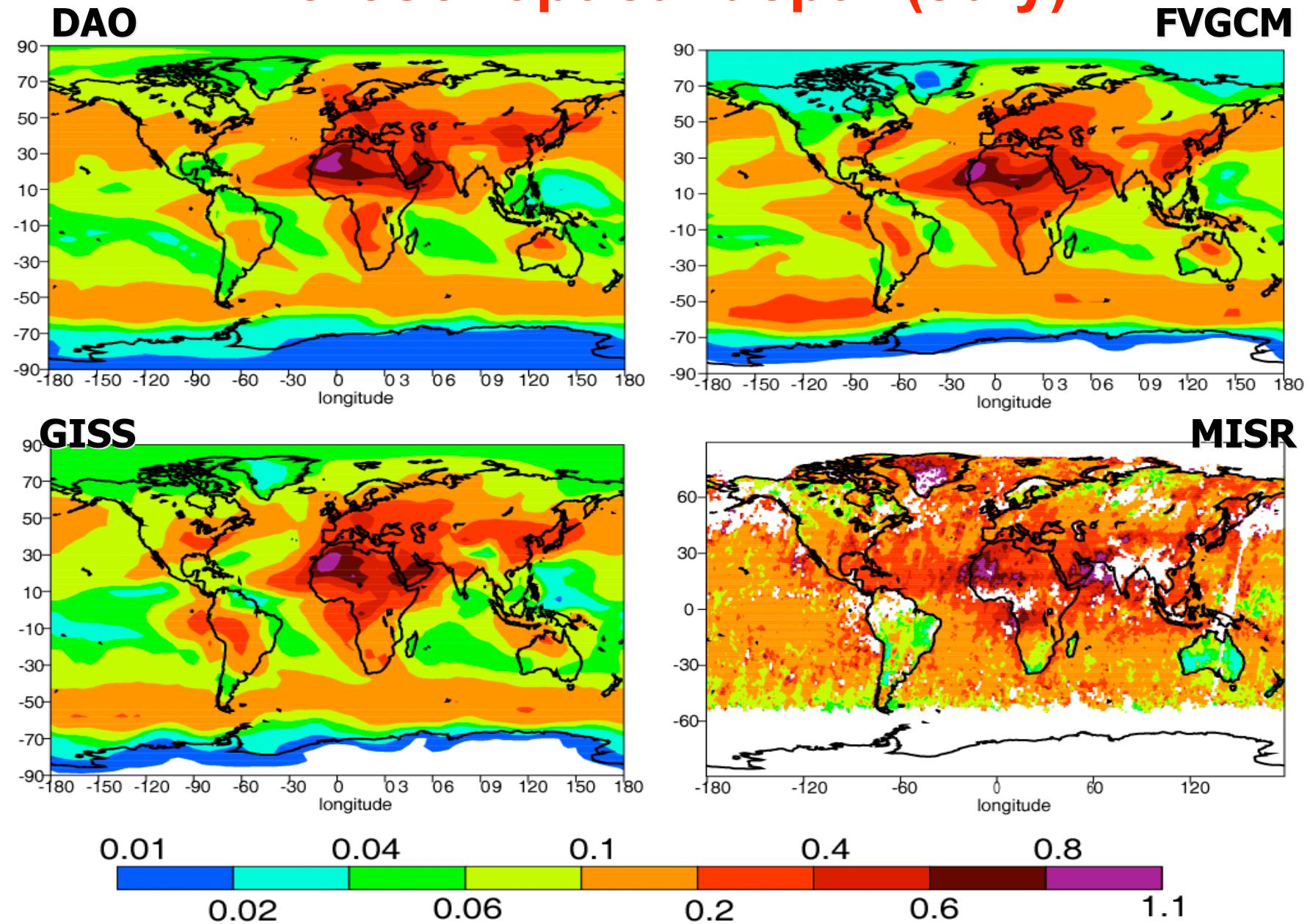
AVHRR



POLDER

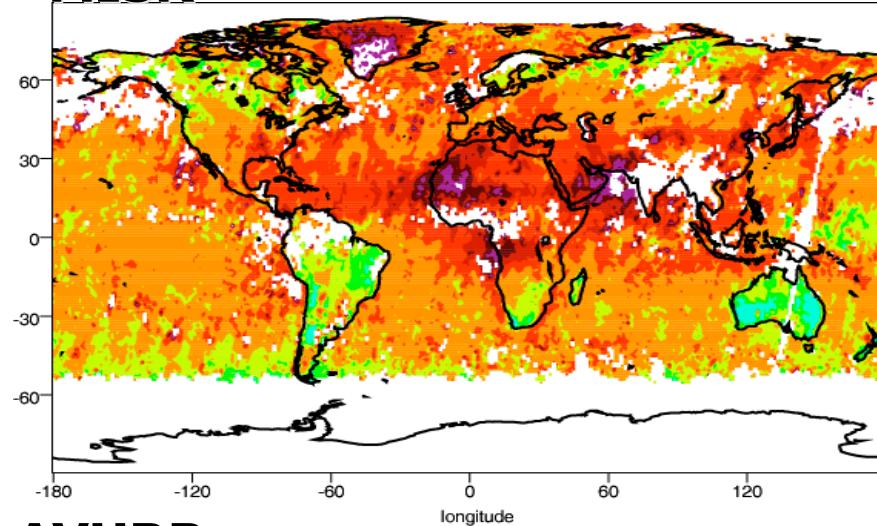


Aerosol optical depth (July)

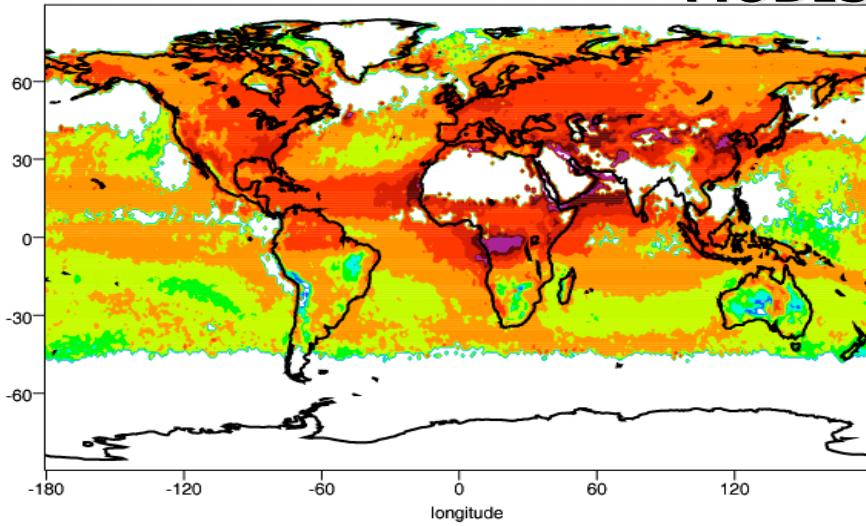


Aerosol optical depth from satellite (July)

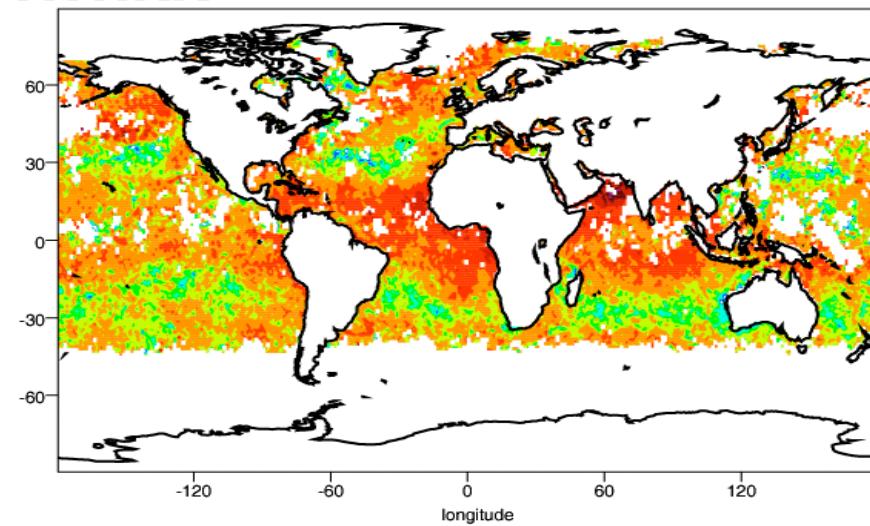
MISR



MODIS



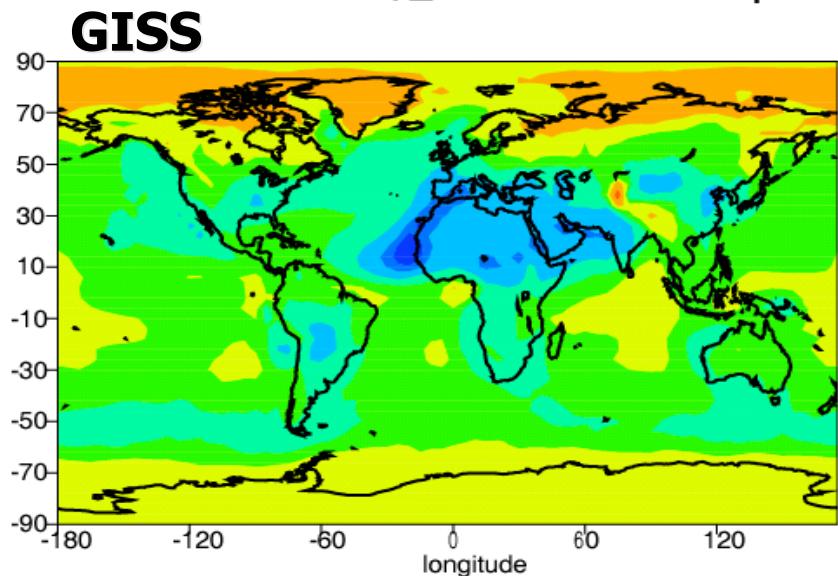
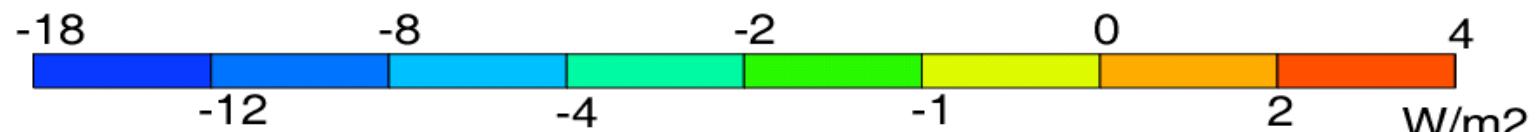
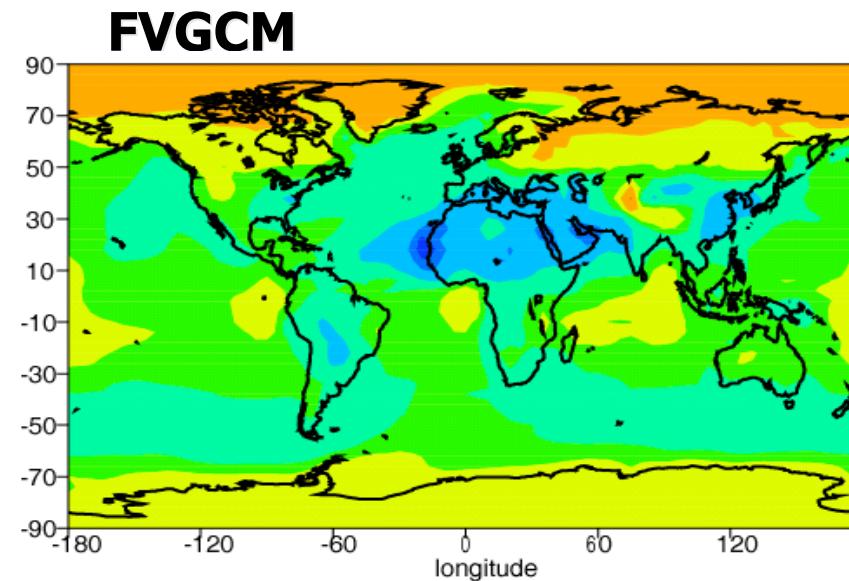
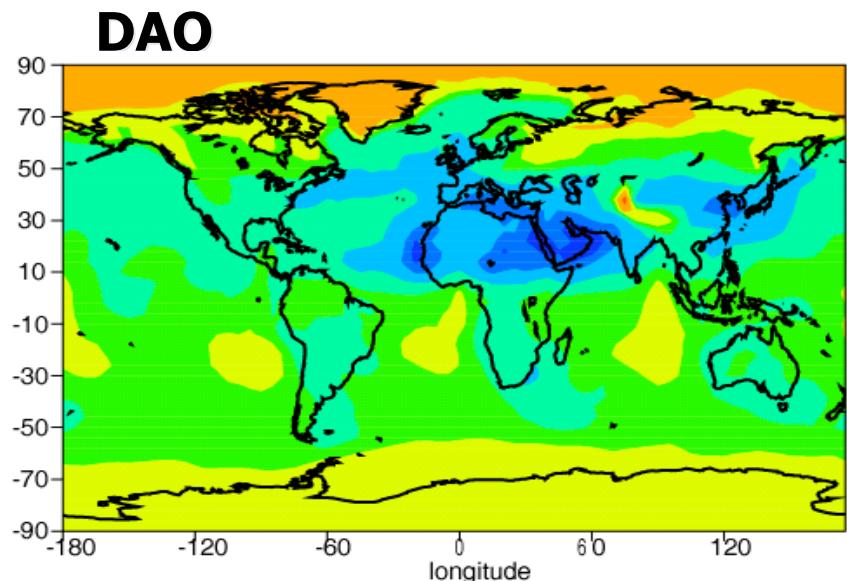
AVHRR



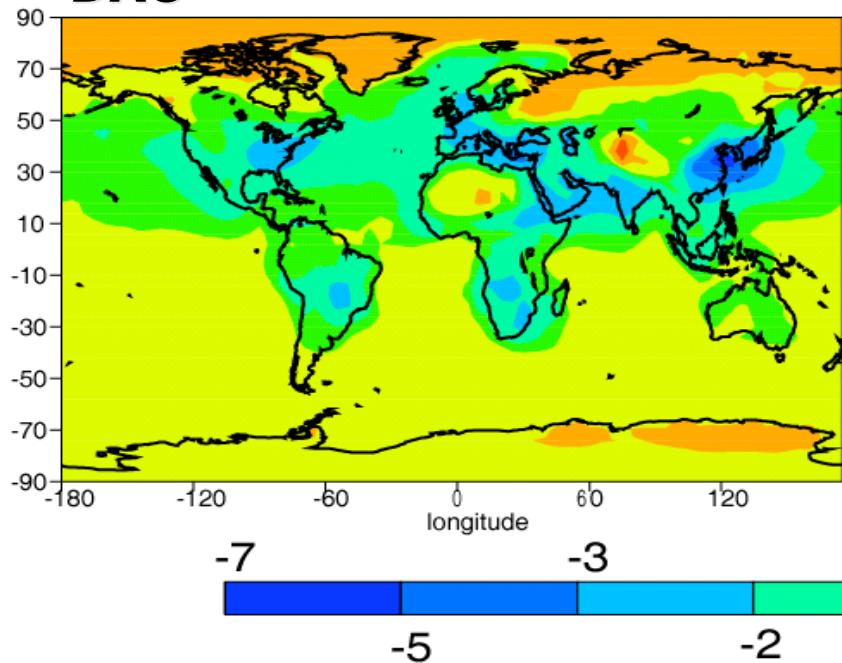
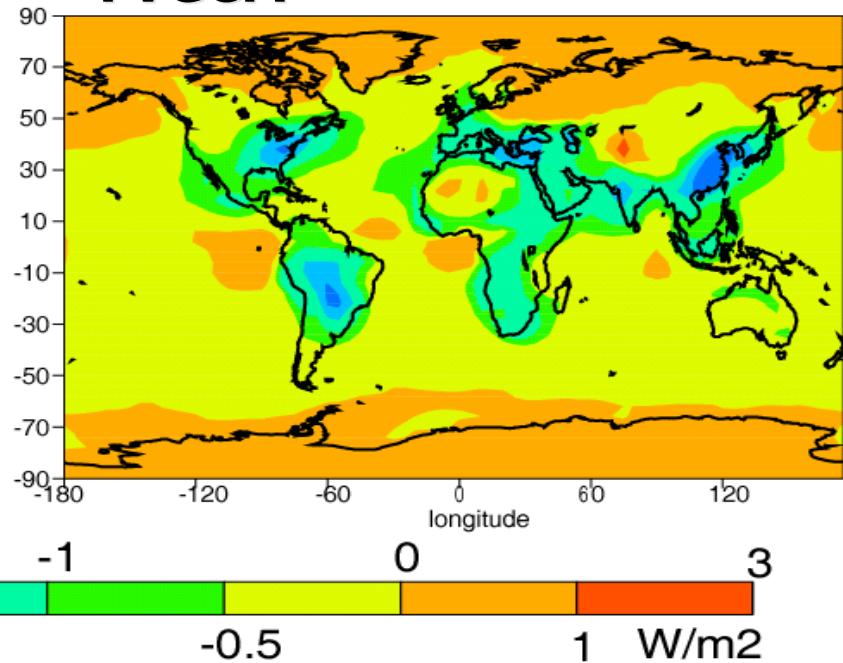
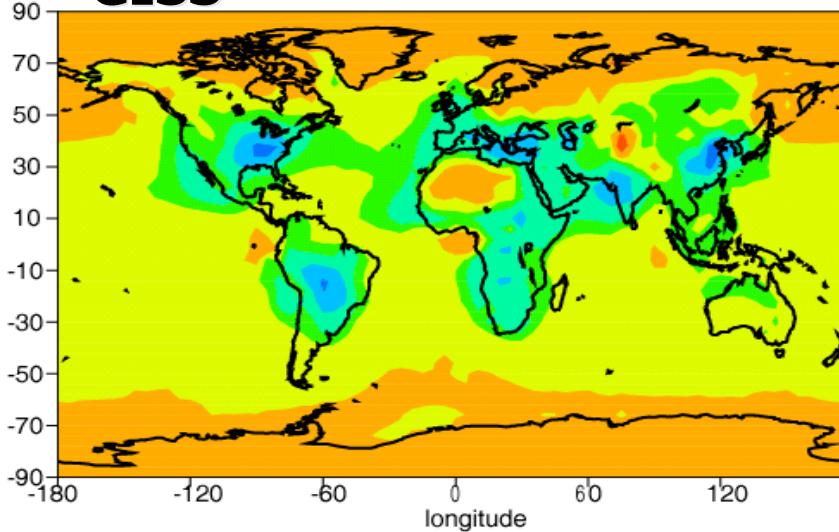
Aerosol optical depth

	DAO	FVGCM	GISS
AOT	0.127	0.134	0.126

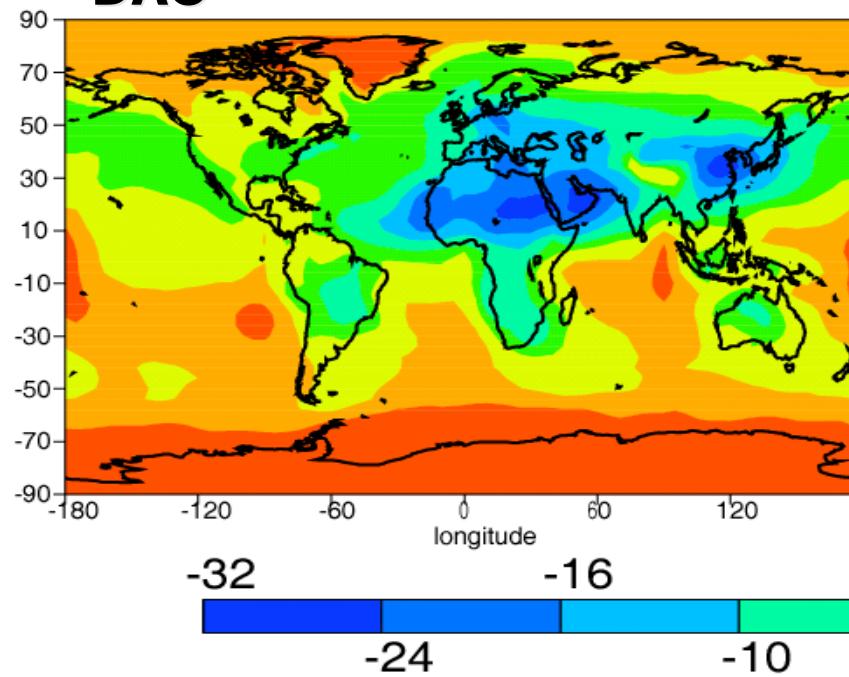
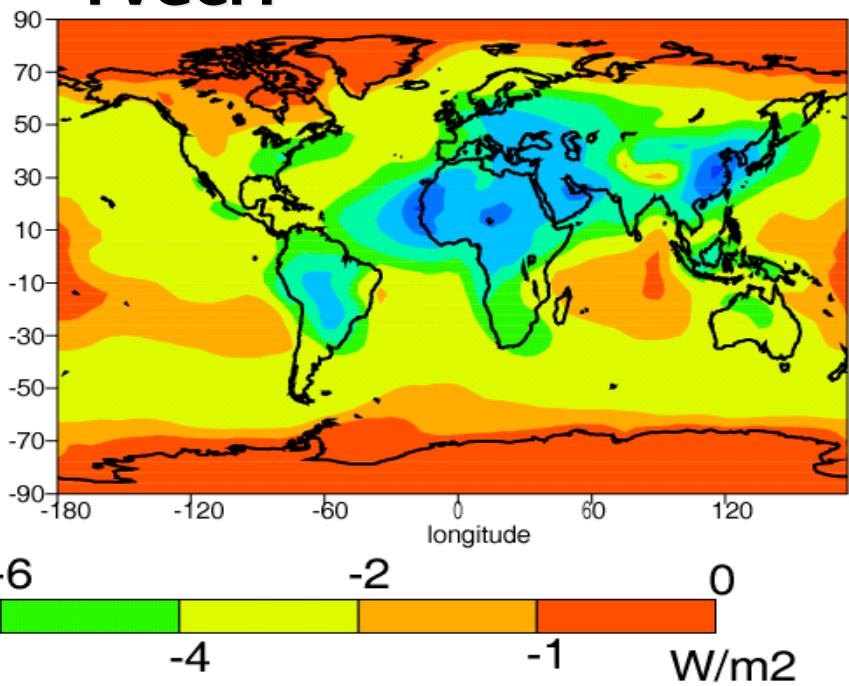
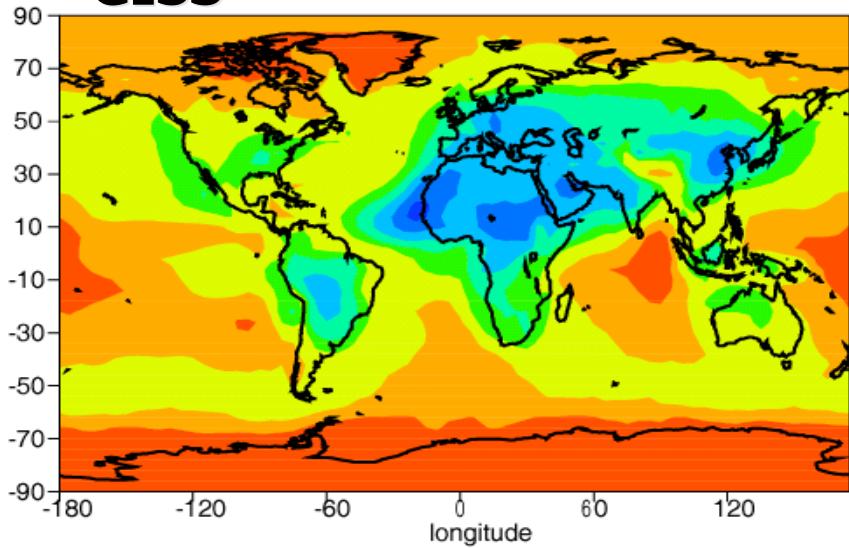
AEROCOM (most models)	0.116-0.155
AERONET	0.14
MODIS-MISR	0.16



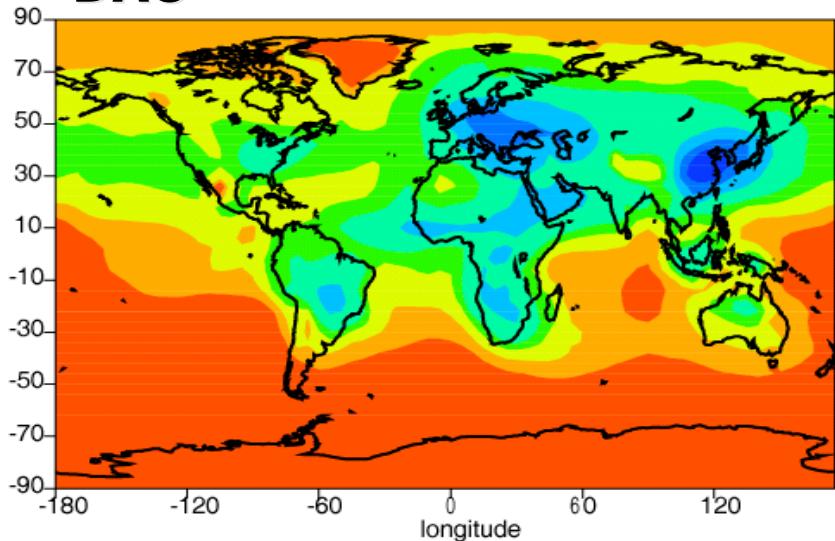
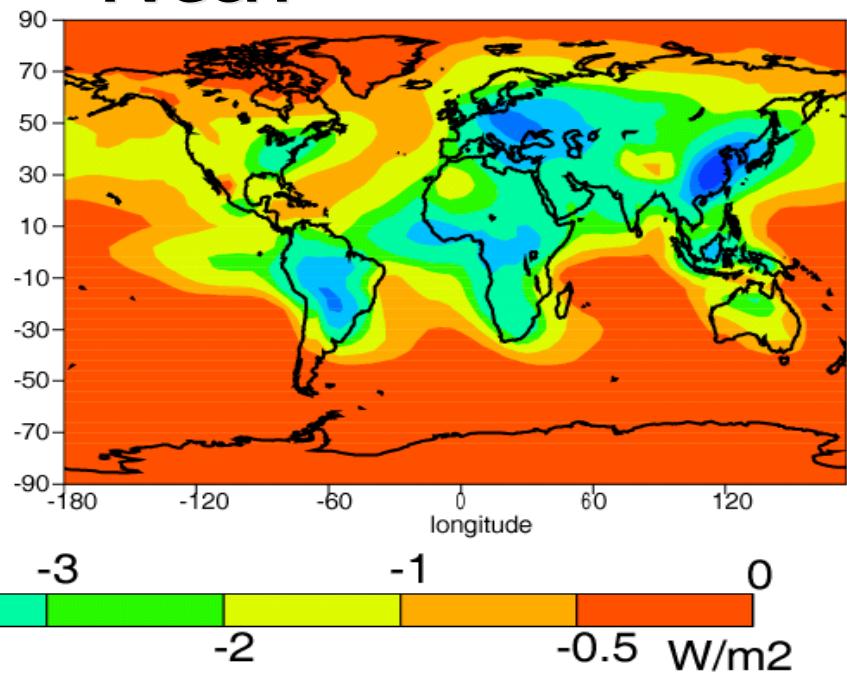
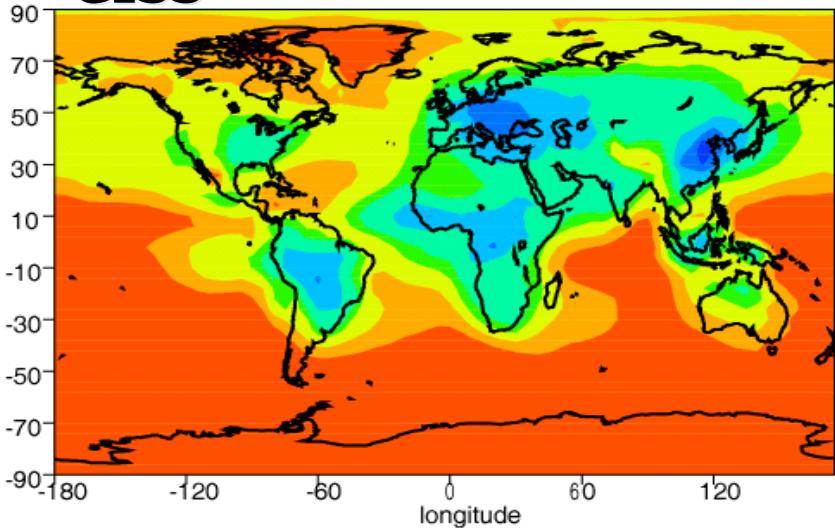
Annual mean present-day aerosol forcing at TOA (all sky)

DAO**FVGCM****GISS**

**Annual mean
anthropogenic aerosol
forcing at TOA (all sky)**

DAO**FVGCM****GISS**

Annual mean present-day aerosol forcing at surface (all sky)

DAO**FVGCM****GISS**

**Annual mean
anthropogenic aerosol
forcing at surface (all sky)**

Clear-sky forcing (-W/m²), present-day aerosol

	DAO	FVGCM	GISS	AEROCOM
at TOA	4.0	4.0	4.0	3.6*, 2.2-5.7
at surface	6.1	6.0	6.1	5.1*, 4.0-10.8

Clear-sky forcing (-W/m²), anthropogenic aerosol

	DAO	FVGCM	GISS	AEROCOM
at TOA	1.3	1.0	1.1	0.8*
at surface	2.7	2.4	2.6	1.6*

* DAO y2000 run submitted to AEROCOM

All-sky forcing (-W/m²), present-day aerosol

	DAO	FVGCM	GISS	AEROCOM
at TOA	2.4	2.1	2.0	2.0*, 0.5-2.6
at surface	4.6	4.1	4.1	3.5*, 1.0-4.0

All-sky forcing (-W/m²), anthropogenic aerosol

	DAO	FVGCM	GISS	AEROCOM
at TOA	0.67	0.35	0.38	0.41*, 0-0.4
at surface	2.1	1.8	1.9	1.2*, 0.9-1.5

* DAO y2000 run submitted to AEROCOM

Summary

- Aerosol distribution patterns associated with 3 met fields are significantly different due to difference in transport, clouds and precipitation.
- Aerosol simulations generally reflect changes of observations, however, improvements are needed for emissions, scavenging schemes...
- Aerosol together with moisture fields (RH, cloud fraction) contribute to large uncertainty in aerosol direct forcing estimations, especially for all-sky cases and on regional scales.